PRELIMINARY ENGINEERING REPORT

FOR

HOPI ARSENIC MITIGATION ALTERNATIVES

IHS Projects PH12-E73, PH11-E55, PH10-E37, PH08-T38, PH06-D33, PH04-S63

PREPARED FOR:

THE HOPI TRIBE

THE HOPI TRIBE
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5448 S. WHITE MOUNTAIN BLVD, STE. 220
LAKESIDE, AZ 85929

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AUGUST 2014

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Acronyms and Abbreviations

AC	Asbestos Cement
ADES	Arizona Department of Economic Security
ADOT	Arizona Department of Transportation
APS	Arizona Public Service
ASL	Above Sea Level
ATSDR	Agency for Toxic Substances and Disease Registry
BGL	Below Ground Level
BHP	Brake Horse Power
BIA	Bureau of Indian Affairs
BIE	Bureau of Indian Education
DBS&A	Daniel B. Stephens & Associates
DOI	Department of the Interior
DWTSA	Drinking Water Tribal Set-Aside
EA	Environmental Assessment
EDU	Equivalent Domestic Unit
FMCV	First Mesa Consolidated Villages
FONSI	Finding of No Significant Impact
FT	Feet
GAL	Gallon
GFH	Granular Ferric Hydroxide
GPCD	Gallons Per Capita Per Day
GPD	Gallons Per Day
GPM	Gallons Per Minute
HAMP	Hopi Arsenic Mitigation Project
HDPE	High Density Polyethylene
hp	Horsepower
HPL	Hopi Partition Lands
HPUA	Hopi Public Utility Authority
HPUC	Hopi Public Utility Commission
HUD	Housing and Urban Development
HWSSP	Hopi Water System Strategic Plan
IHS	Indian Health Service
IN	Inch
JSAI	John Shomaker and Associates, Inc
LCR	Little Colorado River
M	Million
MCL	Maximum Contaminant Level
mg/L	Milligram per Liter
NECA	Navajo Engineering Construction Authority
NEPA	National Environmental Policy Act

NPDWR	National Primary Drinking Water Regulation (USEPA)
NTU	Nephelometric Turbidity Unit
NTUA	Navajo Tribal Utility Authority
O&M	Operations & Maintenance
PER	Preliminary Engineering Report
PMPRo	Project Management Program
ppb	Parts Per Billion
ppm	Parts Per Million
PWS	Public Water System
ROW	Rights-of-Way
R&R	Repair and Rehabilitation
RUS	Rural Utilities Service
SDWA	Safe Drinking Water Act
SFC	Sanitation Facilities Construction Program (IHS)
SMDS	Second Mesa Day School (BIA)
SWA	Sipaulovi Water Association
SWL	Static Water Level
TDH	Total Dynamic Head
TDS	Total Dissolved Solids
USDA-RD	United States Department of Agriculture – Rural Development
USEPA	United States Environmental Protection Agency
WST	Water Storage Tank
YR	Year

1.0 Executive Summary

This Preliminary Engineering Report is the culmination of many years of project planning and development with input and support from multiple federal agencies, tribal employees, tribal leaders, village members, and professional consultants. Completion of this report, and the accompanying Life Cycle Cost Analysis and Comparison of Alternatives, Hopi Public Water System Strategic Plan, and Environmental Assessment, represent a major milestone towards the realization of a drinking water arsenic solution for the affected villages of First and Second Mesa.

The recommended alternative of this report is the construction of a regional water system to serve First and Second Mesa with water on a wholesale basis. This proposed regional water system has become known as the Hopi Arsenic Mitigation Project, or HAMP. The HAMP is considered to be the more sustainable of the two primary alternatives analyzed, and will provide greater operability, reliability, efficiency, simplicity, cost effectiveness, and safety compared to the alternative of implementing water treatment systems in each village.

The keystone of the HAMP are the two newly drilled Turquoise Trail Wells, #2 and #3, which will serve as the new arsenic compliant water source for the villages of First and Second Mesa. The water quality and quantity of the wells have both proven to be outstanding, with arsenic levels of 4.7 and 4.2 ppb, both less than half of the USEPA maximum contaminant level for arsenic in drinking water.

Total costs to implement the HAMP are estimated to be $16.9 million, with the majority of funding expected to be acquired through a loan/grant from the USDA Rural Utilities Service. The HAMP has previously received funding through the EPA and the IHS, with $2.5 million remaining in current EPA funding. The expected USDA loan amount is $1,978,500, after a total of $2.25 million in up-front cash and grant contributions from the Tribe.

Estimated user costs for the HAMP are expected to be $35 a month plus $2.55 per 1,000 gallons of water used per month. Based on reported current water usage from the villages, the cost per average home will be $49.82 per month, plus the cost of local water delivery provided by each respective village, which averages about $17.69 per month, for a total end-user fee of $67.51 per month, for the average project home. This average projected utility rate includes both water and sewer and is within $3 - $13 of the rates similar residents are paying in the Village of Kykotsmovi and at neighboring Keams Canyon.

Items pending and required for completion of the HAMP are submission of the USDA funding application package, formalization of project agreements between the Tribe and the Villages, staffing of the newly created Hopi Public Utility Authority, acquiring full construction funding, construction advertisement and award of a construction contract, construction of the project, and transfer of the new facilities to the HPUA.

2.0 General

2.1 Project Background

In January 2001, the USEPA reduced the drinking water MCL for arsenic from 50 ppb to 10 ppb. Effective January 2006, all public water systems were required to meet this revised standard. Since 2006, the tribal water systems serving the Hopi Villages of First and Second Mesa have been out of compliance with regard to arsenic. Arsenic concentrations in the First and Second Mesa area range from approximately 13 ppb to 20 ppb.

Three of the affected villages (Shungopavi, Sipaulovi, and the FMCV) signed Compliance Plans with the USEPA, Region 9, in 2011, agreeing to bring their respective water systems into compliance with the arsenic MCL by January 23, 2015. These compliance plans are documents that the Drinking Water Office of USEPA, Region 9, issues as a first step in the Region's Enforcement Escalation Policy to implement formal enforcement actions against tribal water systems regulated by USEPA. See Appendix D for copies of the signed Compliance Plans.

In June 2006, the Hopi Tribe received a USEPA Drinking Water Tribal Set-Aside (DWTSA) grant to develop a feasibility study to explore arsenic mitigation compliance strategies (IHS Project PH 06-D33). Through an MOA, the Hopi Tribe requested that the Indian Health Service assist the Tribe in completing an arsenic mitigation study for the First and Second Mesa region. Based on the findings of this investigation, the IHS recommended that arsenic treatment options be avoided to the greatest extent practical and that the arsenic mitigation focus should be directed to non-treatment options. Conveying arsenic compliant water from a proposed well field in the Turquoise Trail region was deemed the preferred strategy for addressing the area's ongoing arsenic compliance challenges. This concept became known as the Hopi Arsenic Mitigation Project.

In 2008, the IHS funded a project to further assist the Tribe in developing the HAMP concept (IHS Project PH08-T38). The project was funded specifically to evaluate the existing Hopi water systems, determine pipeline routes and alignments, identify right-of-way issues, and conduct an environmental assessment of the HAMP.

In 2010, the Tribe received a DWTSA grant for $ 1.9M (IHS Project PH 10-E37), through an Inter-Agency Agreement with the IHS, to further explore and substantiate the HAMP concept. The scope of work defined in the 2010 DWTSA grant included a hydrogeologic study, a utility management plan, and well drilling activities in the Turquoise Trail area.

In 2011, the USEPA awarded the Tribe another DWTSA grant, for $1.1M (IHS Project PH 11-E55), and in 2012 awarded the Hopi Tribe an additional DWTSA grant for $1.2M (IHS Project PH 12-E73), which provided funding for additional planning activities, well drilling, and construction funding for a portion of the HAMP.

IHS Projects E37, E55, and E73, mentioned above, funded the drilling of Turquoise Trail Wells #2 and #3, which were completed in 2014. The completion of Turquoise Trail Wells #2 and #3 was vital to establishing the validity of the HAMP concept and to verifying that an adequate supply of water for the HAMP existed, which would meet all Safe Drinking Water Act (SDWA) standards, including USEPA arsenic standards for drinking water. These wells were successful and can serve as the new arsenic compliant water source for the villages of First and Second Mesa.

USEPA has continued to actively fund the HAMP with the goal of assisting the Tribe in implementing a long-term sustainable arsenic compliance solution. The IHS and the Hopi Water Resources Program, with support from the Tribe, have been actively engaged in advancing the project through public outreach, planning, and preliminary engineering activities. The IHS is committed to assisting the Tribe with engineering and technical support. The HAMP scores high in the IHS Sanitation Deficiency System, but is beyond IHS funding capabilities to fund in its entirety.

2.2 Project Description

The HAMP, as proposed, is a regional drinking water project that encompasses construction of a remote well field, regional water storage tanks, in-line booster pump station, and corresponding transmission pipelines, to convey water from the remote well field to the villages of First and Second Mesa. The Turquoise Trail well field is located approximately 14 miles north of the Hopi Cultural Center in the vicinity of Route 8029, "Turquoise Trail". Bulk water would be delivered to each of the affected villages via a pipeline/transmission system. The IHS commissioned a study known as the Hopi Water System Strategic Plan (HWSSP) to estimate the operational costs of the proposed regional water system and to evaluate potential regional utility organization models. A new utility authority, the Hopi Public Utility Authority (HPUA), has been established to manage and operate the proposed facilities (see Appendix E for the tribal resolution creating the HPUA). Each Village will maintain ownership of, and continue to operate and maintain, their respective water distribution systems, and will purchase bulk water from the proposed regional utility through a master water meter. In this model, the HPUA will act as a water wholesaler to the villages. Villages may be given the option of turning over their respective facilities to the regional utility authority under some future arrangement.

2.3 Community Description

The Hopi Tribe is a union of 12 self-governing Hopi and Tewa villages, created by the villages, under a constitution. The Hopi Tribe is a sovereign nation, with an elected Chairman and representative Tribal Council. The Hopi Constitution vests substantial power in the Tribal Council, which acts by resolution or enactment of laws. According to the Tribe's constitution, the Hopi Tribal Council has the power and authority to represent and speak for the Hopi Tribe in all matters for the welfare of the Tribe, and to negotiate with federal, state and local governments, and with the councils or governments of other tribes. The Hopi Constitution recognizes village authority in specific areas, such as the authority to assign village land for farming, within the traditional clan holdings of the Villages.

The Hopi Reservation is located in northeastern Arizona and occupies portions of Coconino and Navajo counties and encompasses more than 1.5 million acres. The Hopi Villages are generally located on and surrounding the Hopi Mesas.

2.4 Report Format

This Preliminary Engineering Report has been prepared in accordance with USDA-RD guidelines, RUS Bulletin 1780-2, and the January 16, 2013, interagency (USEPA/USDA/IHS/HUD) memorandum regarding best practices in developing preliminary engineering reports. The primary objective of this PER is to fulfill USDA-RD funding application requirements and clearly describe the Tribe's current situation, analyze alternatives, identify and mitigate project risks, and recommend a specific course of action. In so doing, this report fulfills the IHS Sanitation Facilities Construction (SFC) Project Management Program (PMPro) requirements for PMPro Phase 1, Project Development, and partially fulfills the requirements for PMPro Phase 2, Planning & Design.

3.0 PROJECT PLANNING

3.1 LOCATION

The project planning area for this Hopi Arsenic Mitigation Alternatives PER is defined by the existing village water systems on the Hopi Indian Reservation that do not meet SDWA compliance standards for arsenic. All of the villages in the First and Second Mesa areas are currently out of compliance with regard to arsenic levels in drinking water, therefore the project planning area can generally be defined as First and Second Mesa.

3.1.1 FIRST MESA VILLAGES

The villages of First Mesa include Walpi, Tewa, and Sichomovi. The three villages are collectively known as the First Mesa Consolidated Villages (FMCV). First Mesa also encompasses a residential area below the mesa known as Polacca. The mesa top villages of Walpi, Tewa, and Sichomovi, are relatively small in comparison to Polacca, therefore the area in general is often referred to as Polacca. For the purposes of this report, the First Mesa villages and residential areas are collectively referred to as FMCV. All of First Mesa is served by a common water utility, operated by the FMCV, from the same source water wells.

3.1.2 SECOND MESA VILLAGES

Second Mesa is comprised of the villages of Sipaulovi, Mishongnovi, and Shungopavi. Both Sipaulovi and Mishongnovi have upper and lower components to their villages. The "upper" villages are located on top of the mesa and the "lower" villages are situated at the southern base of the mesa. Sipaulovi and Mishongnovi are currently served by common shared water systems, with one water system serving the upper villages and a separate system serving the lower villages. The village of Shungopavi has the largest population of the three Second Mesa villages and is generally located on the southwest end of the mesa. Shungopavi operates its own separate water system.

In general, Hopi village boundaries are not well defined and some overlap of village defined lands exists.

3.1.3 BIA WATER SYSTEMS

An exception to the planning area defined above are the homes, schools and administrative buildings served by the Bureau of Indian Affairs (BIA) and Bureau of Indian Education (BIE) water systems in and around the described planning area. The BIA owns and operates a water system in the Keams Canyon area to serve tribal residences, US Government staff housing, the Hopi Police Station, and the BIA maintenance and administrative complex. The BIE owns and operates two water systems, one to serve the Hopi Junior/Senior High School complex, and the other to serve the Second Mesa Day School (SMDS). All three of the BIA/BIE water systems are currently utilizing treatment systems to remove arsenic from their source water wells, before consumption by their water users. The Tribe and the Department of the Interior (DOI) have initiated a potential HAMP related partnership, and the DOI has expressed interest in further evaluating and negotiating a partnership with the Tribe. There are numerous factors for the Tribe and the DOI to consider when evaluating a potential partnership including construction cost sharing, service agreement details, fee structure and rates, and cost effectiveness, to name a few.

The Tribe, IHS, and the DOI's Office of Facility Management and Construction (OFMC), on behalf of the Assistant Secretary for Indian Affairs, have drafted a planning project and memorandum of agreement (see Appendix I) to further evaluate the possibility of the Tribe serving the BIA and BIE water systems through the HAMP. The draft planning project would be funded through contributions from all three entities. The planning project work would be accomplished by the IHS, and would include publishing addendums to the engineering documents (EA/PER/HWSSP) to include the BIA and BIE. The draft memorandum of agreement between the OFMC and the IHS is being reviewed now by IHS legal counsel.

Whereas the planning work to evaluate inclusion of the BIA/BIE into the HAMP is not yet complete, the BIA/BIE financial and managerial components are omitted from the corresponding engineering and financial calculations in this report. If in the future the Tribe and the DOI mutually decide that the BIA/BIE water systems should participate in the HAMP, then this report will need to be amended with the addition of a BIA/BIE addendum section. It should be noted that the proposed alternatives presented in this PER have not been sized to accommodate the additional flows required to serve the BIA/BIE systems.

3.1.4 Tawa'ovi Planned Development

Currently, the only planned development in the project planning area is the master planned community of Tawa'ovi, which is located approximately 15 miles north of Second Mesa, and about one mile north of the newly drilled Turquoise Well #2. The Tawa'ovi community project is currently in the planning stages and the HAMP project team has been routinely coordinating with the Tawa'ovi team. Continued communication between the two project teams is recommended and the final design of the HAMP facilities may consider a future Tawa'ovi connection, if funded separately by the Tribe. Initial plans for this connection were based on the assumption that the existing Turquoise Trail Well #1 would be rehabilitated and utilized as a production well for the HAMP. Further investigations into the feasibility of rehabilitating Turquoise Trail Well #1 brought into question the value of rehabilitating the well due to the age of the well, unknown construction methods and tolerances, the limited production capacity, incomplete penetration of the N-aquifer, and the fact that the well's production zone is unscreened open borehole. The limited production capacity is a consequence of the nominal 8 inch diameter well casing, which subsequently limits the size and capacity of the potential submersible pump equipment. The Tawa'ovi community could be connected to the HAMP, to provide redundancy and an emergency second water source. A Tawa'ovi connection to the HAMP would need to be funded by the Tribe or others, as the expected funding sources of the HAMP (EPA, USDA, and IHS) are not typically available to fund new developments. In addition, the Tribe would need to contribute a pro-rata contribution to the HAMP to fund a corresponding increase in HAMP facility sizing to accommodate Tawa'ovi's water demand. Tawa'ovi water usage estimates range from minor initially to an estimated average day demand of

300 gpm at full build-out. The HAMP, as proposed herein, has not been sized to accommodate the additional flow required to serve Tawa'ovi.

3.1.5 Third Mesa

The existing villages of Third Mesa are outside of the planning area, as the Third Mesa villages are currently arsenic compliant. An expansion of the HAMP to Third Mesa would be at the Tribe's cost, and would be solely to provide additional supply/capacity to Third Mesa. Previously acquired funding for the HAMP has been granted on the basis of public health and arsenic compliance for First and Second Mesa. An expansion to Third Mesa would require upsizing the HAMP facilities and water sources, and constructing a pipeline eastward to the Third Mesa villages. Due to the excessive capital cost of such an expansion, and the emphasis on arsenic compliance, the Third Mesa expansion, and corresponding increase in water source capacity and facility sizing, has not been designed into the HAMP.

3.1.6 Future Expansions and Connections

All HAMP pipelines are designated as transmission mains, and future small or individual service connections are highly discouraged. Future connections to the transmission main should generally include a consecutive water storage tank and distribution system. Future connections should carefully consider hydraulic impacts to the regional system and limit flows to acceptable rates.

Figure 3.1 – General Location Map

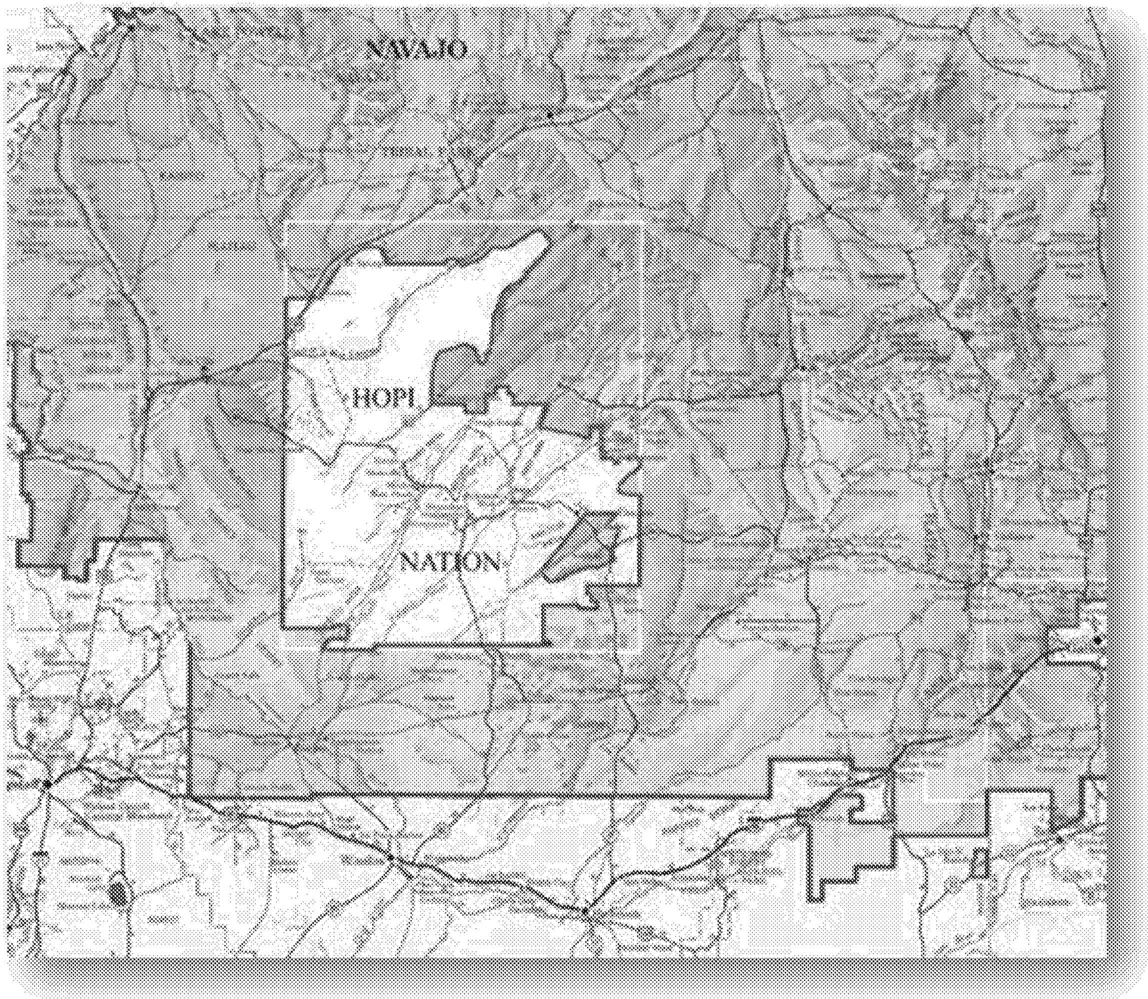

FIGURE 3.2 – HOPI LOCATION MAP

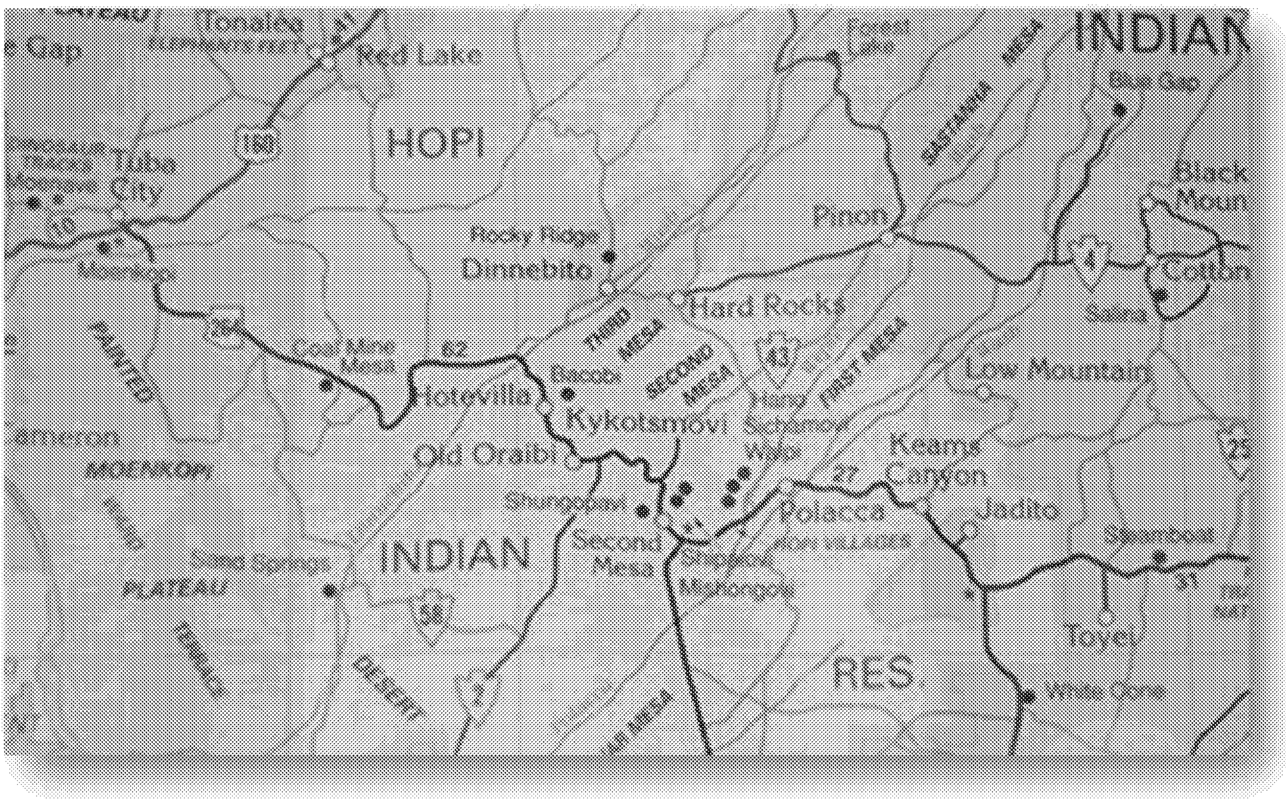

FIGURE 3.3 – LOCATION OF HOPI VILLAGES AND MAJOR ROADS

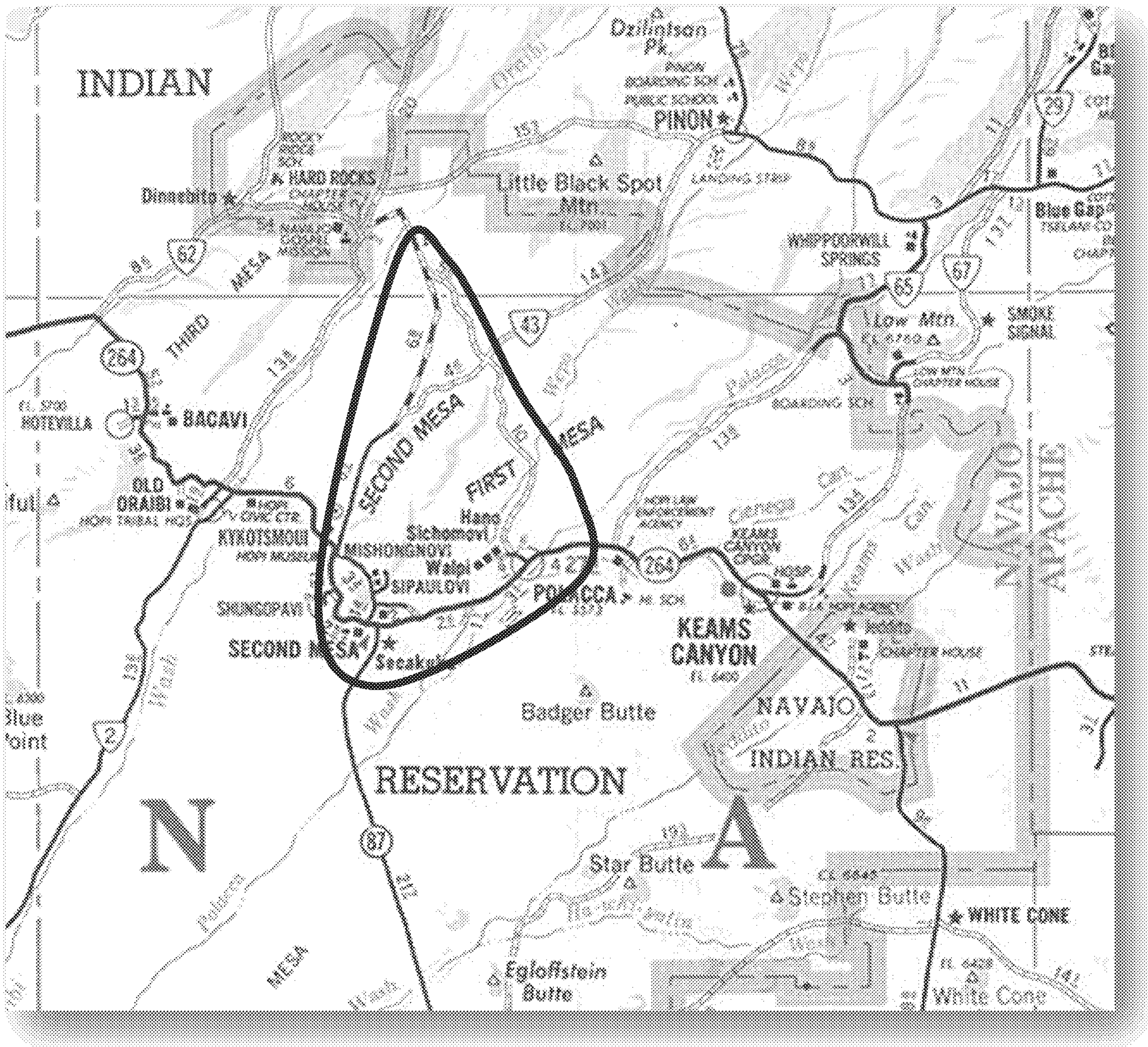

FIGURE 3.4 – PROJECT VICINITY MAP

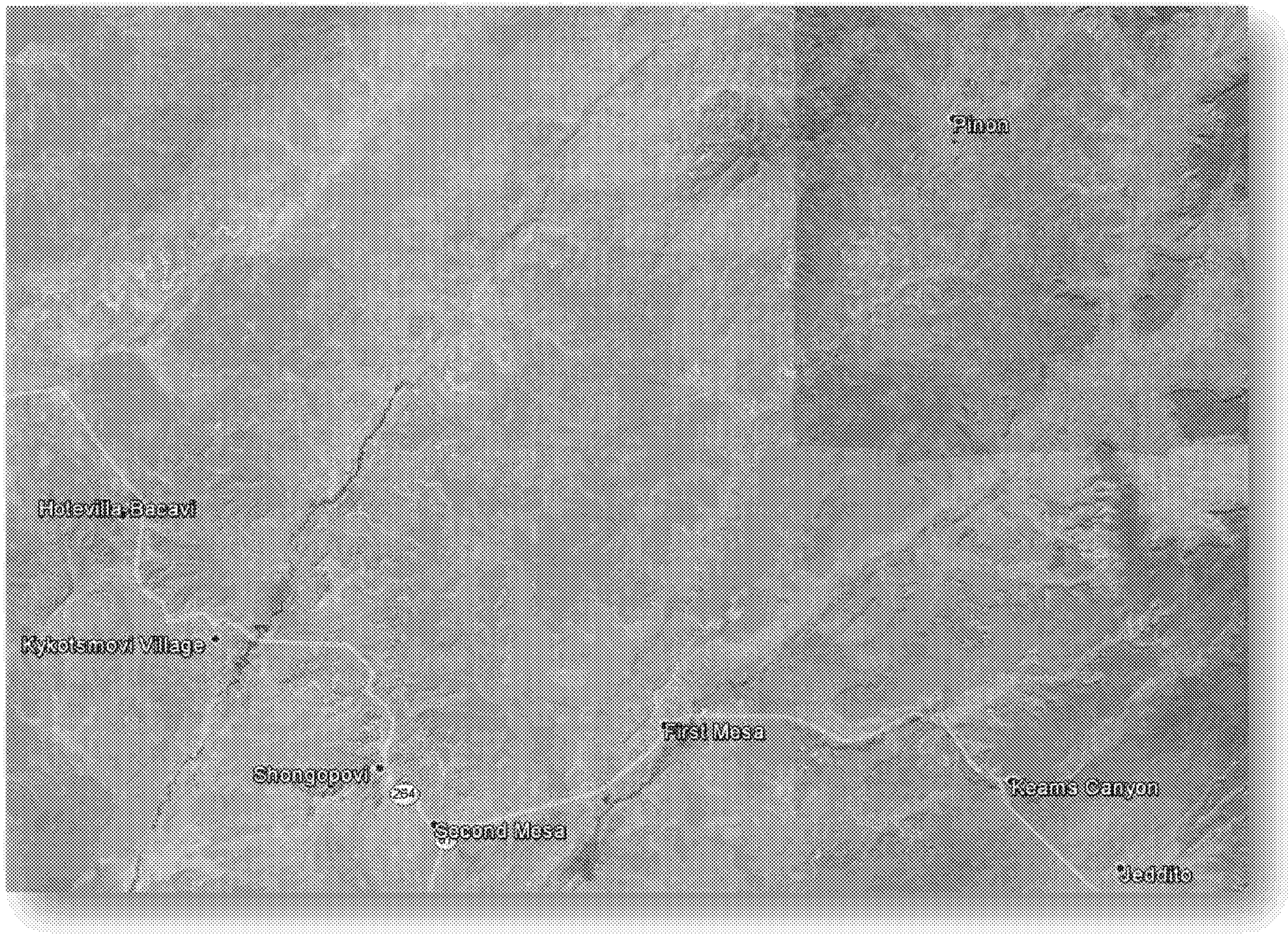

FIGURE 3.5 – SATELLITE PHOTO OF PROJECT VICINITY

3.2 ENVIRONMENTAL RESOURCES

An Environmental Assessment (EA) has been completed which describes HAMP alternatives, the affected environment, and anticipated environmental impacts. The Indian Health Service is the lead agency and cooperating agencies include the Hopi Tribe, Bureau of Indian Affairs, Bureau of Reclamation, U.S. Department of Housing and Urban Development, U.S. Department of Agriculture – Rural Development, and U.S. Environmental Protection Agency. The EA incorporates relevant NEPA requirements and guidelines from all the cooperating agencies.

In accordance with 40 CFR Parts 1500-1508, a full range of environmental resources has been considered in the EA. The project will have no impact on wild and scenic rivers, endangered and threatened species, wilderness areas, national natural landmarks, prime farmland, or explosive and flammable operations, since there are none of these resources in the project vicinity. The project would have minor impacts on topography, geology, soils, climate and air quality, wetlands, solid and hazardous wastes, transportation, environmental justice, Indian trust assets, and airport clear zones.

Environmental resources with more potential for impacts include groundwater, floodplains, vegetation, fish and wildlife, environmentally sensitive areas, cultural resources sites, aesthetic and visual resources, land use, surface water, socioeconomics, public health and safety. The relative impact on each of these resources was considered for each alternative. Please refer to the Environmental Assesment for more detail on environmental resources and impacts.

3.3 Population Growth Trends

Historical US Census population data has been used to estimate population growth trends for First and Second Mesa. Table 3.1 summarizes the 2000 and 2010 US Census data.

Table 3.1 – 2000 to 2010 US Census Data and Population Growth

<table>
<tr><th></th><th colspan="2">First Mesa</th><th colspan="2">Second Mesa</th><th colspan="2">Shungopavi</th><th colspan="2">Keams Canyon</th><th>Weighted Average</th></tr>
<tr><td>Occupied Housing Units - 2010 US Census</td><td>438</td><td rowspan="2">3.82%</td><td>247</td><td rowspan="2">2.71%</td><td>204</td><td rowspan="2">2.65%</td><td>104</td><td rowspan="2">4.04%</td><td rowspan="2">3.33%</td></tr>
<tr><td>Occupied Housing Units - 2000 US Census</td><td>301</td><td>189</td><td>157</td><td>70</td></tr>
<tr><td>Population - 2010 US Census</td><td>1,555</td><td rowspan="2">3.30%</td><td>962</td><td rowspan="2">1.68%</td><td>831</td><td rowspan="2">2.78%</td><td>304</td><td rowspan="2">1.58%</td><td rowspan="2">2.61%</td></tr>
<tr><td>Population - 2000 US Census</td><td>1,124</td><td>814</td><td>632</td><td>260</td></tr>
<tr><td>Average Annual Increase from 2000 to 2010</td><td colspan="2">3.56%</td><td colspan="2">2.20%</td><td colspan="2">2.71%</td><td colspan="2">2.81%</td><td>2.97%</td></tr>
</table>

Where:

*Future Population = Current Population * (1+%GrowthRate)^(# of years)*

Table 3.2 – Average Persons per Home

First Mesa	Second Mesa	Shungopavi	Keams Canyon	Weighted Average
3.6	3.9	4.1	2.9	3.7

Based on 2010 US Census Population and Number of Occupied Housing Units Data

Population projections and population recommendations were also obtained and compared from the Arizona Department of Economic Security (ADES), Volume 2 of the May 2003 Western Navajo-Hopi Water Supply Study prepared by HDR Engineering for the Bureau of Reclamation, the 2006 Hopi

Source Water Assessment prepared by Tetra Tech for the Hopi Tribe, the 2012 draft version of this PER, and the comments received from the USDA to the 2012 draft PER.

The following table, Table 3.3, summarizes the projected population growth rates for a 20 year planning period, from an assumed project start date of 2015 (for additional tables and calculations see Appendix H).

Based upon a comparison of the available data, summarized below, it is recognized that there is a range of possible population growth rates through 2035, with a probable range somewhere between 0.85 – 2.75% annually, for the areas of First and Second Mesa. Recognizing that population projections are forward looking and are best estimates of future unknowns, a geometric growth rate of 1.8% was settled upon as a moderate estimate at the exact midpoint of the probable range of growth rates.

TABLE 3.3 – POPULATION GROWTH RATE PROJECTION

	2000 - 2010 Average Growth Rate	Estimated Range of Possible Growth Rates through 2035	Suggested Population Growth Rate through 2035
US Census - Population	2.61%		
US Census - Occupied Housing	3.33%		
ADES		0.85 - 0.93%	0.93%
TetraTech (2006 report)			2.0%
HDR (2003 report)		1.3 - 2.75%	2.5%
2012 Draft PER			2.0%
USDA (2012 draft PER comments)		1.0 - 1.25%	
This Report:		**0.85 – 2.75%**	**1.8%**

The recommended population growth rate of 1.8% will be used in this PER to project population growth and the corresponding growth in water demand through the year 2035, through the end of the 20 year project planning period.

Note that discrepancies exist between the US Census population and housing numbers and the number of residences reported as being served by the village utilities. This is mainly due to the fact that not all residences within First and Second Mesa are served with community water. It may also be due to the US Census and the villages having slightly differing definitions of the boundaries of each of the Mesas.

3.4 COMMUNITY ENGAGEMENT

The IHS, EPA, and the Tribe have all actively sought to engage the villages and other affected stakeholders, to ensure that the project meets the needs and desires of the entire community. The

IHS and the Tribe have hosted many community outreach meetings over the last eight years as the project has progressed through the planning and development process, including several site visits with local village leaders. Several of the community meetings were in fulfillment of the NEPA process. Several of the community meetings were to specifically address design and planning questions with the local villages and others. Design data and current O&M data was collected from each of the villages and the BIA. The EPA has hosted, and will continue to host, a monthly HAMP update call, open to the public, where project information is disseminated and regular communications with village leaders and other project stakeholders is conducted. The IHS, EPA, and Tribal leaders have also met with the Tribal Council, to keep the Council apprised of the project's status and progress. A portion of this outreach effort to project stakeholders is documented in the HAMP Environmental Assessment, which also documents the specific consultation conducted with over 30 governmental organizations.

4.0 Existing Facilities

Hopi Villages are generally autonomous on issues that involve their water & wastewater systems, with villages owning and operating their individual water & wastewater systems independently of the Tribe. Consolidated systems do exist, such as the First Mesa Consolidated Villages (FMCV) system, which serves the villages of First Mesa and the community of Polacca. The FMCV exists as a result of individual autonomous villages coming together to form the utility cooperative, and not as a result of tribal policy or tribal planning.

The following sections provide a brief description of the existing village water systems. Refer to Appendix C for system schematics and pressure zone maps of the existing village water systems.

4.1 First Mesa Consolidated Villages

The existing FMCV water system spans four pressure zones. Drinking water for the entire system is currently produced from two functioning wells, which are identified as Wells #6 and #8. These wells each have capacities of approximately 100 GPM. Wells #1, 2, 3 and 4 have been abandoned, and wells #5 and 7 are currently not in use. Pressure zone #1 is the uppermost zone and services the homes on top of the mesa. Subsequent zones are labeled in order of decreasing elevation. Pressure zone #1 has an 8,000 gallon storage tank and a 1,000 gallon hydropneumatic tank with a corresponding booster pump. Pressure zone #2 consists of a 500,000 gallon water storage tank (Polacca East Tank) fed by well #8 and provides service to a few higher elevation homes located below the mesa. Pressure zone #2 feeds pressure zone #3 through two pressure reducing valves (PRV #8 and #9) and generally serves the majority of Polacca homes north of Highway 264. Pressure zone #3 feeds pressure zone #4 through a series of five PRVs (PRVs #6, 4, 3, 2, 1) located along and just north of Highway 264. Pressure zone #4 generally serves homes south of Hwy 264 and east of the hospital, which is served by the 200,000 gallon Polacca West Tank, Well #5, and, in back-up mode, by pressure zone #3 through PRV #7. Water is boosted from pressure zone #2 up to pressure zone #1 via a small duplex booster pump station.

The FMCV water system currently serves 580 residential service connections, 19 commercial, and 21 "other" water service connections. Note that not all residences within Polacca and the FMCV villages have water service.

4.2 Shungopavi

The existing Shungopavi water system consists of one well producing approximately 65 GPM and one 250,000-gallon elevated water storage tank. One pressure zone serves the entire village with pressure being provided by the elevated storage tank. A new well was drilled in Shungopavi in 2008, which exhibited high arsenic concentrations of 33 ppb. The new well was subsequently never put into service.

The Shungopavi water system currently serves 146 residential service connections, no commercial, and three "other" water service connections. Note that not all Shungopavi residences currently have water service.

4.3 Upper Sipaulovi/Mishongnovi

The Upper Sipaulovi/Mishongnovi water system consists of two pressure zones, one well which produces approximately 9 GPM, one 16,000-gallon water storage tank and one hydropneumatic tank with a corresponding booster pump.

The Upper Sipaulovi/Mishongnovi water system currently serves 25 residential service connections, no commercial, and one "other" water service connection. Not all Upper Sipaulovi/Mishongnovi residences currently have water service.

4.4 Lower Sipaulovi/Mishongnovi

The Lower Sipaulovi/Mishongnovi water system consists of one well which produces approximately 90 GPM, a 75,000-gallon water storage tank, and a gravity-fed distribution system.

The Lower Sipaulovi/Mishongnovi water system currently serves 100 residential service connections, three commercial, and five "other" water service connections. Not all Lower Sipaulovi/Mishongnovi residences currently have water service.

4.5 History of Existing Facilities

Almost all of the existing facilities described herein have been constructed or upgraded over the past several decades with assistance from the Indian Health Service (excluding those served by the BIA) under the authority of Public Law (PL) 86-121. PL 86-121 was signed into law in 1959, creating the IHS SFC program and authorized the IHS SFC to provide essential water supply, sewage, and solid waste disposal facilities to American Indian and Alaska Native homes and communities. The IHS SFC program has historically provided technical assistance to the Tribe on sanitation facility projects, regardless of the funding source.

4.6 Condition of Existing Facilities

Generally speaking, the existing water facilities are serviceable, and when major facilities become unserviceable they regularly qualify for upgrading through the IHS SFC program. Electro-mechanical system components (i.e. well pumps, booster pumps, chlorination pumps, etc.) tend to wear faster and are more maintenance intensive than other water system components (i.e. water mains, storage reservoirs, etc.). Therefore, these components tend to be in the least serviceable condition.

Three facilities which have outlived, or are nearing, their expected design life and should be considered for replacement, are the three wells which serve Second Mesa. Specifically, the Shungopavi well is 45 years old, the Upper Sipaulovi-Mishongnovi well is 35 years old, and the

Lower Sipaulovi-Mishongnovi well is 36 years old. Well casings and screens are generally expected to be serviceable for about 40 years.

4.7 Financial Status of Existing Facilities

The existing village utilities rely heavily on grant funding for major water system expansions and capital upgrades. IHS, USEPA, HUD, and USDA-RD are the most common federal agencies who fund capital improvements to the benefit of the Villages and the Tribe. No federal agencies supplement the cost of the Village's day-to-day operations of their water and sewer systems.

Billing methods and rate structures for water and sewer service vary by village. The current billing practices and annual O&M costs for the individual village water systems are summarized below (see also Appendix H for more detailed information on annual operating expenses).

FMCV – The FMCV utility organization currently charges most residential services a flat rate of $15.00 per month and most commercial services $52.00 per month for combined water and sewer service. The FMCV charges the IHS hospital and Polacca Elementary at a rate of $12 per month plus $0.0085 per gallon.

FMCV's 2013 self-reported annual water system O&M costs were approximately $184,000. The FMCV does not subsidize its utility operations with village or tribal funds, and meets all of its annual expenses through billing of utility customers.

Shungopavi – Beginning in January 2014, the Village of Shungopavi began charging users for water and sewer service. Previously, the Village did not bill its members for water or sewer, with utility operating costs being subsidized entirely by the Village.

The new utility rates are $20 per month for homes with community water and sewer, $15 per month for homes with only community water and an individually owned septic tank, and $10 per month for homes with no community water or sewer, but which haul water from a community watering point. The elderly are eligible for a reduced utility rate, upon request.

Shungopavi's 2013 self-reported annual water system O&M costs were approximately $141,000. With the new billing structure, Shungopavi plans to pay for most or all of its utility operations through billing of utility customers.

Sipaulovi/Mishongnovi – The Village of Sipaulovi maintains the combined Upper Sipaulovi/Mishongnovi water system and the combined Lower Sipaulovi/Mishongnovi water system. Day-to-day operations are managed by the Sipaulovi Water Association. The SWA bills residential connections $12.00 per month for the first 1,000 gallons and then $3 for each additional 1,000 gallons thereafter. Businesses pay $30.00 per month for the first 1,000 gallons then $3 per thousand thereafter.

The SWA provides water service to eight yard hydrants in Upper Sipaulovi, and collects $8 per month on those yard hydrants. The SWA also provides water service to two yard hydrants in Upper Mishongnovi, though the SWA is currently unable to bill for those two services. The SWA is evaluating options to either collect the monthly utility bill for the two yard hydrants serving the Upper Village of Mishongnovi, or turn the operation of the Mishongnovi side of the combined water system over to the Village of Mishongnovi or to the newly created HPUA.

The SWA's 2013 self-reported annual water system O&M costs were approximately $76,000. The SWA does not subsidize its utility operations with village or tribal funds, and meets all of its annual expenses through billing of utility customers.

5.0 Need For Project

5.1 Public Health

The USEPA established an interim National Primary Drinking Water Regulation (NPDWR) in 1975 with an MCL for arsenic in drinking water of 50 ppb. The interim NPDWR was fully adopted by Congress in 1986, with Congress directing the USEPA to revise and re-evaluate the NPDWR. In January 2001, the USEPA updated the NPDWR and lowered the MCL for drinking water concentrations of arsenic to 10 ppb. Public water systems in the United States were to comply with the new arsenic MCL by January 2006.

All Village water systems at First and Second Mesa have been out of compliance since January 2006 with the USEPA MCL for arsenic in drinking water. The arsenic concentration of village drinking water systems currently ranges from approximately 13 ppb to 20 ppb. Shungopavi, Sipaulovi, and the FMCV each signed Compliance Plans with the USEPA in 2011, agreeing to bring their respective water systems into compliance with the arsenic MCL by January 2015 (see Appendix D for the signed Compliance Plans). The primary objective of this PER is to evaluate alternatives to bring the affected village water systems into compliance by supplying safe drinking water with arsenic concentrations below 10 ppb.

Arsenic (As) is a toxic element, well known for centuries as an effective poison, largely due to the inability of humans to smell or taste it. Arsenic occurs naturally as the highly soluble arsenite, As(III), and arsenate, As(V), ions. Arsenic can also form compounds with oxygen, chlorine, sulfur, carbon, hydrogen, lead, mercury, gold, and iron. Its high solubility makes it easily transportable in water formations. Arsenic is the 20th most abundant element in the earth's crust and is commonplace in the earth's atmosphere, soil, rocks, organisms, and water. Most often, arsenic enters drinking water sources through natural weathering processes, geochemical reactions, volcanic emissions, and other natural processes.

The primary route for human exposure to arsenic is through ingestion of arsenic in drinking water. Human exposure to arsenic may lead to varying chronic and acute health effects. Chronic ingestion of low doses of arsenic over time may result in an increased risk of skin, lung, liver, bladder, kidney, and colon cancer; as well as, pigmentation changes of the skin, skin thickening, neurological disorders, muscular weakness, circulatory and hormonal dysfunctions, loss of appetite, and nausea. Because of the possible human health risks associated with ingestion of arsenic in drinking water, the USEPA regulates the allowable level of arsenic in public drinking water systems, and may further re-evaluate the current arsenic MCL in the future.

Some representative historical arsenic data for wells in the First and Second Mesa area is found in Table 5.1 below.

TABLE 5.1 – HISTORICAL ARSENIC DATA FOR FIRST AND SECOND MESA AREA WELLS

Well	Date	Arsenic Concentration (ppb)
Upper Sipaulovi - Mishongnovi	11/7/1990	8
	8/13/2002	17
	11/9/2004	13
	1/24/2006	16
	6/26/2007	18
	3/26/2008	17
	1/27/2009	16
	12/17/2009	18
	3/29/2010	18
Lower Sipaulovi - Mishongnovi	5/24/1979	12
	2/15/1983	20
	9/23/1993	18
	8/3/2000	17
	7/30/2002	15
	6/1/2005	21
	6/26/2007	18
	8/19/2008	20
	12/17/2009	20
	3/29/2010	19
Shungopavi	5/24/1979	12
	2/15/1983	20
	2/20/1991	13
	10/14/1997	13
	7/8/2003	16
	6/1/2005	17
	6/25/2007	15
	7/1/2008	15
	3/10/2009	16
	3/23/2010	14
Hopi High School	9/29/1987	20
	12/26/2006	26
	3/10/2009	26
	1/5/2010	23

Well	Date	Arsenic Concentration (ppb)
FMCV #1	1/2/1996	20
	5/27/1998	4
FMCV #5	1/2/1996	20
	5/27/1998	4
	11/26/2001	20
	7/21/2005	20
	9/20/2005	14
	10/18/2005	14
FMCV #6	6/8/1994	5
	1/2/1996	10
	5/27/1998	1
	11/26/2001	17
FMCV #7	2/21/1996	23
	11/26/2001	20
FMCV #8	11/26/2001	18
	9/20/2005	18
	10/18/2005	17
	8/7/2007	20
	1/6/2009	18
SMDS	5/24/1979	14
	2/15/1983	20
	7/27/1994	12
	1/30/2002	18
	10/5/2007	18
Keams Canyon BIA	2/16/1983	20
	8/28/1989	40
	7/27/1994	33
	1/26/1998	40
	5/10/2006	39
	1/24/2007	35

Note that some of the low arsenic concentration values, below 10 ppb, may correspond with inactive periods, when the well was not being actively pumped; and therefore, not inducing leakage from the D aquifer to the N aquifer. See section 6.1 of this report for a further discussion of D and N aquifer leakage.

5.2 System Operations and Maintenance

Although the primary objective of the proposed project is to improve public health through compliance with the arsenic rule, O&M requirements have been a principal consideration during project development and planning. Preference is given to the most sustainable alternative, from an O&M standpoint, which also complies with the arsenic rule and the SDWA.

5.3 Growth Considerations

In addition to meeting SDWA standards, this project seeks to provide adequate water sources to meet the villages' projected water demands over the project planning period.

5.3.1 Water Use Trends

Water conservation on the Hopi Reservation is interwoven with the Hopi culture and traditional values. According to Hopi tribal members, the Hopi's instinctive practice of conserving water stems from a history of limited drinking water supply. Per capita water usage rates for First and Second Mesa average approximately 58 GPCD (see Table 5.2 below).

Table 5.2 – Estimated EDU and Per Capita Water Usage

	No. of Resid-ential Services	2013 Reported Annual Production Volume (gallons)	Average Monthly Metered Non Residential Usage (Gal/Mo)	Estimated Equivalent Domestic Unit (EDU) Monthly Usage (Gal/Mo)	EDU Daily Usage (GPD)	Estimated Persons per Home based on 2010 US Census	Estimated Per Capita Usage (GPCD)	No. of EDU
Shungopavi	146	10,402,600	NR	5,938	195	4.1	48	146
Sipaulovi Mishongovi (lower)	100	7,142,300	NR	5,952	196	3.9	50	100
Sipaulovi Mishongovi (upper)	25	2,102,600	NR	7,009	230	3.9	59	25
FMCV	580	49,953,900	226,000	6,788	223	3.6	62	613
Total/Weighted Average		**69,601,400**	**226,000**	**6,550**	**215**	**3.7**	**58**	**884**

NR = none reported

Hopi water usage is substantially lower than the national average. According to the American Water Works Association, the national average per capita water use is 69 GPCD for indoor use, and 101 GPCD for outdoor use, for a combined total of 170 GPCD. Numerous discussions among the project stakeholders, including IHS, USEPA, Hopi Water Resources Program, and Village members and leaders, have concluded that upon completion of this project an increasing trend in water usage will likely be realized. Factors contributing to this anticipated increase include:

Water availability – It is anticipated that upon completion of this project water will be perceived as being more readily available, which could lead to some degree of relaxation of the traditional Hopi water conservation philosophy. This potential increase in water usage would result in a general uptrend in per capita usage. In time, and with greater water availability, Hopi water usage may reach parity with national per capita water use averages.

Accessibility – The HAMP will inherently increase accessibility to water service, by virtue of constructing pipelines through areas that currently do not have access to water. Proposed HAMP pipeline alignments fall in close proximity to village residences that currently do not have water service or indoor plumbing, and future tribal projects may extend from the HAMP to serve those currently unserved homes, leading to increased water usage.

To account for the potential increase in per capita water usage and potential increase in number of plumbed homes with water service, a 50% increase in water consumption has been factored into the projected 2035 peak water demands for First and Second Mesa.

5.3.2 Water Use Projections

Estimated water demands through the 20 year planning period are shown in Table 5.3, below. The criteria used to estimate First and Second Mesa water demands are the following:

- Planning period of 20 years used for facility sizing (may be different than facility useful life);
- Geometric population growth rate of 1.8% per year assumed over the planning period;
- Average per capita water consumption is assumed to increase by up to 50% by the end of the planning period;
- Reported village water production is assumed to be equivalent to total per capita water consumption;
- Average annual village water production is used to project water demands, with a multiplier of 1.5 (Navajo Area IHS peak factor, see Appendix H) to account for variations in seasonal water usage, such as during peak summer months, or during times of the year that religious festivals increase monthly and daily water demands;
- Water sources and water delivery facilities should be sized to handle expected peak flows.

TABLE 5.3 – ESTIMATED WATER DEMANDS, 1.8% GROWTH RATE THROUGH 2035

	Number of Residential Services	Number of "other" Services	Total Number of Services	2013 Reported Annual Production Volume (gallons)	2013 Reported Annual Average Production (GPM)	Year 2015 Peak Design Demand (GPM)	Year 2035 Peak Design Demand (GPM)
Shungopavi	146	3	149	10,402,600	19.8	30.8	58.6
Sipaulovi Mishongovi (lower)	100	8	108	7,142,300	13.6	21.1	40.3
Sipaulovi Mishongovi (upper)	25	1	26	2,102,600	4	6.2	11.8
FMCV	580	40	620	49,953,900	95	147.7	281.3
Total without BIA				**69,601,400**	**132.4**	**205.8**	**392**
2nd. Mesa Day School	14	3	17	1,800,000	3.4	5.3	10.1
Keams Canyon	200	6	206	21,497,050	40.9	63.6	121.1
Hopi Jr./Sr. High School	48	13	61	6,501,000	12.4	19.3	36.7
Total with BIA/BIE				**99,399,450**	**189.1**	**294.0**	**559.9**

Year 2015 Peak Design Demand = (2013 Annual Average Production)(1.5)*(1.018^2)*
Year 2035 Peak Design Demand = (2013 Annual Average Production)(2.0)*(1.018^22)*

6.0 ALTERNATIVES CONSIDERED

Four alternatives are herein considered for arsenic mitigation: modification or rehabilitation of existing Hopi wells to produce arsenic compliant drinking water, water treatment for arsenic by the individual villages, and a non-treatment regional water system alternative, otherwise known as the HAMP, and the fourth alternative of taking no action.

Multiple hybrid alternatives of the Treatment and Non-Treatment Alternatives could be derived, consisting of treatment for some villages and HAMP for other villages, but those possible hybrid alternatives are not considered herein.

6.1 MODIFICATION OR REHABILITATION OF EXISTING HOPI WELLS

One USDA suggestion to the 2012 Draft PER was to evaluate the existing water wells which serve First and Second Mesa, to determine if they could be rehabilitated or modified to prevent the production of arsenic non-compliant water. That suggestion will be addressed briefly here, and is only summarily evaluated as an alternative, primarily because there are no known strata from which the existing wells produce water, which would be arsenic compliant without treatment.

The Turquoise Trail Hydrogeologic Study, prepared for the Indian Health Service in 2011 by Kennedy Jenks, includes information about the formations and aquifers surrounding the Hopi Reservation. The focus of the Hydrogeologic Study was to investigate the hydrogeology of the Turquoise Trail area, but includes information regarding the hydrogeology near the existing villages of First and Second Mesa.

The Kennedy Jenks Hydrogeologic Study states that the most hydrologically important geologic formations in the area (because of water quantity and quality) are the Navajo and Kayenta Formations, which comprise the N-aquifer. The thickness of the Navajo and Kayenta Formations decreases from about 950 feet near Shonto, Arizona, north of the Hopi Reservation, to about 500 feet in thickness in the Turquoise Trail region, at the northern border of Hopi, to zero feet in thickness at the southern and eastern edges of the Hopi Reservation. The two other local aquifers are the C-aquifer, which is deeper than the N-aquifer, and has poorer water quality than the N-aquifer, and the D-aquifer, which is about 100 feet in thickness near the Hopi Mesas, and overlies the N-aquifer, and is also of generally poorer water quality than the N-aquifer.

There exists a confining layer between the N and D aquifers, primarily composed of the Carmel Formation, which is substantial going north from the Hopi Mesas, and becomes thinner in the area of the Hopi Mesas and to the south. This confining layer separates the N and D aquifers and accounts for their distinct water quality characteristics. Although, in the southern half of the Hopi Reservation, the confining layer thins to the point that leakage from the D-aquifer into the N occurs, and therefore the groundwater chemistry of the two aquifers becomes similar.

Corresponding to the comingling of the N and D aquifers in the southern portion of the Hopi Reservation, the N-aquifer in the area of the Hopi Mesas exhibits arsenic concentrations generally above 10 ppb, with documented occurrences up to 79 ppm (Kennedy Jenks, 2011).

"The thickness of the Carmel Formation increases to the north as its grain size also decreases, making it a more competent confining layer, potentially decreasing the migration of arsenic and other constituents into the N Aquifer via leakage from the D Aquifer." (Kennedy/Jenks, 2011)

Speaking of the southern portion of the N-aquifer near the Hopi Mesas, it is not precisely known where arsenic enters the N-aquifer, as the overlying D-aquifer, although of much poorer water quality in general than the N-aquifer, does not exhibit the >10 ppm arsenic concentrations that the N-aquifer exhibits. Tetra Tech discussed this phenomenon in their 2005 Hopi Source Water Assessment, and theorized that the arsenic is possibly present in the confining layers between the N and D aquifers, and is transported to the N-aquifer by leakage from the D-aquifer, in those areas where leakage is occurring. This would explain why arsenic concentrations above 10 ppm in the N-aquifer correspond to areas of D-aquifer leakage, despite the fact that the D-aquifer does not exhibit the >10 ppm arsenic concentrations.

As the majority of municipal water wells at First and Second Mesa are producing from the N-aquifer, there is no readily apparent way to seal or blind off specific screened intervals of the existing wells to reduce production of arsenic non-compliant water, considering the homogeneity of the N-aquifer, the generalized thinness of the N-aquifer, the thinness of its overlying confining layer, the leakage between the N and D aquifers, and the generalized arsenic concentrations of the N-aquifer in this area. Therefore, based on this understanding of the hydrogeology of the area, and based on the known arsenic concentrations of the N-aquifer in this area, it is assumed that all wells of the First and Second Mesa area will be of similar water quality, with arsenic concentrations greater than 10 ppm.

6.2 The Treatment Alternative

An individual water treatment system, for each affected village water system, is here considered as an arsenic mitigation solution for the water systems of First and Second Mesa.

Note that the original draft PER, of April 2012, only briefly considered water treatment as an arsenic mitigation alternative, due to the fact that adequately operating and maintaining an arsenic removal/treatment system requires a high level of water system operator skill and proficiency. It is common among rural areas served by the IHS to find that water systems relying upon water treatment technologies are not receiving the full-benefit of those treatment technologies, and that in some cases, due to malfunction or disrepair of the treatment system, no treatment is being provided before consumption by the public. For example, the arsenic treatment systems at Keams Canyon, the Hopi High School, and the SMDS, all operated by the BIA, have historically had difficulty maintaining arsenic compliance. The BIA was recently fined $123,000 in civil penalties, in

September 2013, for repeated non-compliance of its Keams Canyon water system, in regards to arsenic concentrations and arsenic reporting requirements, despite the BIA having spent more than $1,000,000 to install an arsenic treatment system at Keams Canyon (see USEPA press release in Appendix D).

The IHS continues to advocate that arsenic treatment for the Villages of First and Second Mesa is not in the best interest of public health, due to the difficulty of adequately maintaining and operating an arsenic treatment system.

Despite the IHS position on arsenic treatment, treatment as an arsenic mitigation alternative is herein evaluated, to fully establish the pros and cons of decentralized arsenic treatment and outline how the treatment alternative would function for each village.

6.2.1 Design Criteria, Treatment Alternative

The design criteria and design assumptions for the Treatment Alternative are as follow:

- Planning period of 20 years used for facility sizing (may be different than facility useful life);
- Geometric population growth rate of 1.8% per year assumed over the planning period;
- Average per capita water consumption is assumed to increase by up to 50% by the end of the planning period;
- Reported village water production is assumed to be equivalent to total per capita water consumption;
- Average annual village water production is used to project water demands, with a multiplier of 1.5 (Navajo Area IHS peak factor, see Appendix H) to account for variations in seasonal water usage, such as during peak summer months, or during times of the year that religious festivals increase monthly and daily water demands;
- Water sources and water delivery facilities should be sized to handle expected peak flows;
- Existing water sources will be treated to remove arsenic and comply with all SDWA requirements;
- Village water source wells must have the combined capacity to meet the village water system's demands in 12 hours of pumping, following Navajo Area IHS Guidelines;
- More than one water source well is required per village, to provide redundancy and allow for down-time for maintenance operations;
- Each village well must be a viable water source with the capacity to meet the design demand for the duration of the design life of the project;
- Additional village water sources may be needed to meet the 20-year design demand;
- Additional villages water sources will be assumed to be arsenic non-compliant, and treatment for arsenic will be needed;
- The possibility of rehabilitating or modifying existing village water wells to prevent the production of arsenic non-compliant water is not technically feasible;
- Where grid power exists, diesel generators must also be provided as backup power, to address the possibility of an extended, multi-day power outage;

- Water storage requirements for the Treatment Alternative shall be per Navajo Area IHS Guidelines: 2.5 days of water storage, plus any fire flow reserves, less the production from the remaining water sources over 18 hours, assuming the largest producing well is out of service;
- Water storage for fire flow reserves is to be omitted, as none of the affected Villages have firefighting capabilities;
- Each village will continue to own and operate its own respective distribution system;
- Each village will continue to be responsible for maintaining disinfection throughout its distribution system;
- Each village will continue to be responsible for the collection of utility fees from its individual customers;
- The newly created HPUA will only act in an advisory role to the existing village water systems.

6.2.2 Treatment Alternative Maps

See Appendix B for maps and diagrams of the Treatment Alternative in each Village.

6.2.3 Existing Water Sources at First and Second Mesa

The following tables highlight the water chemistry and well construction data for the existing production wells within the planning area.

Table 6.1 – Representative Groundwater Chemistry, First and Second Mesa

		Keams Canyon Wells 2 & 3, Composite	FMCV Well #8	Lower Sipaulovi - Mishongnovi Well	Upper Sipaulovi Well	Second Mesa Day School Well	New Shungopavi Well	Shungopavi Well
Arsenic	ppb	38	20	18	18	19	33	15
TDS	mg/L	648	380	350	330	340	350	300
Sulfate	mg/L	55	17	18	16	15	22	21
Iron	mg/L	< 0.05	0.11	0.26	< 0.05	< 0.05	0.22	< 0.05
pH		9.4	9.6	9.7	9.7	9.7	9.94	9.8
Turbidity	NTU	< 1	< 1	3.3	< 1	< 1	2.4	< 1
Silica	mg/L	13	15	18	18	17	24	19
Vanadium	mg/L	< 0.05	< 0.05	1.5	1.5	1.7	unknown	0.33
Alkalinity	mg/L	359	320	280	270	290	240	240

All existing production wells in the planning area produce water containing arsenic above the US EPA MCL of 10 ppb. All existing production wells will require arsenic treatment to be compliant with the arsenic rule. There are no known wells existing in the planning area which readily comply with the arsenic rule, without requiring arsenic treatment.

TABLE 6.2 – WELL DATA FOR EXISTING FIRST AND SECOND MESA VILLAGE WELLS

	FMCV Well #5	FMCV Well #6	FMCV Well #8	Shungopavi Well	New Shungopavi Well	Upper Sipaulovi - Mishongnovi Well	Lower Sipaulovi - Mishongnovi Well
Arsenic (ppb)	18	12	20	16	33	18	18
Yield (GPM)	100	100	110	65		9	90
Total Depth (FT BGL)	915	915	1,100	1,530	1,620	1,442	983
Pump Set (FT BGL)			822	1,113			651
Drop Pipe (IN)			4	2			3
Static Water Level (FT BGL)	182	158	365	990		779	430
Motor Size (hp)	40	40	40	35		5	20
Smallest Casing Diameter (IN)	8	8	6	6	6-5/8	7	6
Ground Elevation	5,633	5,633	5,730	6,352	6,370	6,190	5,790
Year Constructed	1986	1986	1988	1969	2008	1979	1978
Current Age	28	28	26	45	6	35	36

Note that the existing Shungopavi well, Lower Sipaulovi/Mishongnovi Well, and Upper Sipaulovi/Mishongnovi well, have exceeded or are approaching their expected design life of 40 years. Replacement of these wells will be needed, as the Treatment Alternative will rely upon these wells for another 20 years through the duration of the project planning period.

6.2.4 ARSENIC REMOVAL PROCESS

The arsenic removal processes evaluated for providing arsenic treatment are found in greater detail in the Life Cycle Cost Analysis and Comparison of Arsenic Mitigation Alternatives report, published by GHD and OEM Services (GHD and OEM, 2014).

Three treatment systems were evaluated; those being:

- A reverse osmosis membrane system;
- An ion exchange, alumina or iron based granular media sorption system;

- A precipitative system using chemical addition to oxidize and precipitate arsenic compounds.

An Ion exchange sorption system was selected as the preferred arsenic removal process, based on cost and other factors. The Siemens PV 2000 package system, with a capacity of 100 GPM, was selected as the preferred treatment system for this alternatives evaluation. The PV 2000 uses granular ferric hydroxide (GFH) media within low pressure steel vessels to adsorb the arsenic into the media as it passes through the vessel.

6.2.4.1 Arsenic Speciation

Arsenic in drinking water is present as arsenate, As(V), and arsenite, As(III). Surface waters tend to be predominantly arsenate and ground waters tend to be a mixture of arsenate and arsenite. Most treatment technologies, including the PV 2000 package system, are most effective at removing arsenic in the arsenate form. The following table summarizes the arsenic speciation in the region's existing wells.

Table 6.3 – Arsenic Speciation

		Keams Canyon Wells 2 & 3, Composite	FMCV Well #8	Lower Sipaulovi - Mishongnovi Well	Upper Sipaulovi Well	Second Mesa Day School Well	New Shungopavi Well	Shungopavi Well
Arsenic, Total	mg/L	0.038	0.02	0.018	0.018	0.019	0.033	0.015
Arsenic, As(V)	mg/L	0.012	0.004	0	0.0158	0	unknown	0.01
Arsenic, As(III)	mg/L	0.026	0.016	<0.0020	0.0022	<0.002	unknown	0.005
% As(III)	%	68%	80%	0%	12%	0%	unknown	33%

For maximum removal of arsenic from drinking water, arsenite should be oxidized to arsenate, before applying treatment. Addition of a strong oxidizer, such as sodium hypochlorite, will be used in the pretreatment process.

6.2.4.2 Adjustment of pH for Arsenic Treatment

All of the existing First and Second Mesa wells have high pH. Arsenic treatment technologies are most effective with pH levels close to neutral; therefore a significant pretreatment pH adjustment will be required for effective and efficient arsenic removal. A minimum pH adjustment to 7.5 - 8.5 will be required prior to arsenic treatment. Hydrochloric acid will be used in the pretreatment process to lower production water pH.

6.2.4.3 Competing Ions

Many arsenic removal technologies, including ion exchange sorption, rely on physical and chemical reactions to occur to effectively remove arsenic. Water may contain several other anions (negatively charged ions), in addition to the arsenate anions, that will be preferentially removed before the arsenate anion. These anions are referred to as competing ions and they can greatly decrease the efficiency of an arsenic treatment system. Competing anions such as silicate, phosphate, fluoride, vanadium, carbonate, and sulfate can dramatically reduce arsenic adsorption, and also dramatically reduce the potential life of the sorption media.

The groundwater in the First and Second Mesa region contains several of the primary constituents that provide the anions that compete with arsenate for removal; those being primarily vanadium, sulfate, and silica. At 1.5 mg/L, the vanadium found in the Sipaulovi wells is 30 times higher than what the state of California has determined is suitable for drinking water, although it is not directly regulated by the SDWA. Reportedly, the Keams Canyon BIA arsenic treatment facility has already experienced a more rapid rate of adsorptive media decline due to vanadium and other competing ions than would be expected if it were just removing arsenate. Competing ions in the region's groundwater will undoubtedly affect the arsenic removal efficiency and media service life of a sorption system.

6.2.5 Detailed Description of the Treatment Alternative

Each village water system will require an arsenic treatment facility to remove the naturally occurring arsenic from the village's groundwater. Several villages will require additional water sources and water storage to meet their projected water demands through the planning period. Water transmission mains will be required to transport untreated well water to the centralized village water treatment facilities. Finished water leaving the treatment facility will comply with all SDWA requirements, including disinfection. For each village, the finished water will be pumped from the treatment facility to a local water storage tank, where it will then gravity feed into the village's existing distribution system. The minimum capacity of each treatment facility is equal to the sum of the capacity of the village water wells.

Table 6.4 – Village Treatment Facilities, Minimum Required Capacities

	Elevation	Minimum Capacity (GPM)
FMCV	5,730	465
Sipaulovi/Mishongnovi	5,790	140
Shungopavi	6,352	120

Table 6.5 – Additional Village Water Source Capacity Required

	Expected Yield (GPM)
Future FMCV Well	255
Future Lower Sipaulovi Well	50
New Shungopavi Well	55

TABLE 6.6 – ADDITIONAL WATER STORAGE REQUIRED, PROPOSED VILLAGE STORAGE

	Existing Capacity (GAL)	Current (2013) Days of Water Storage	Year 2035 Days of Water Storage (Existing)	Storage Required to Meet Navajo Area Guidelines (GAL)	Additional Storage Required (GAL)	Proposed Storage (GAL)
East Polacca Tank	500,000	5.2	1.7	904,680	196,680	200,000
West Polacca Tank	200,000					
Upper First Mesa Tank	8,000					
Shungopavi Tank	250,000	8.8	3.0	140,760	-	-
Lower Sipaulovi Tank	75,000	3.8	1.3	91,080	16,080	100,000
Upper Sipaulovi/Mishongnovi Tank	16,000	2.8	0.9	84,960	68,960	

6.2.5.1 FMCV TREATMENT DESCRIPTION

The existing FMCV water system is supplied with water from three existing water sources, FMCV Well #5, Well #6, and Well #8. Well #5 is currently off-line but could be brought back on-line with a rehabilitation of the well controls and electrical system, which is included in the FMCV treatment cost estimate. The three existing water sources have a combined capacity of about 310 GPM. To meet the projected design demand per the design criteria, the FMCV needs an additional 255 GPM of water source yield. This additional water source will need to be drilled and proven before the treatment alternative is determined to be completely feasible. Hydrogeologic consulting services will need to be obtained to provide well design and development recommendations, and to provide on-site well inspection during well drilling.

The FMCV water treatment facility would be sited next to existing Well #8, where electric power exists, and an existing water main would serve as a dedicated fill line from the treatment facility to the East Polacca Tank. A booster pump located within the treatment facility would boost finished water up to the East Polacca Tank. Water transmission mains from Wells #5 and #6, and from the new well to be drilled, would be required to transport untreated water to the treatment facility. An additional 200,000 gallons of water storage is required to meet design guidelines, and would best be sited next to the existing East Polacca Tank. Backup generators will be required at each well site and the treatment facility to provide power during power outages.

6.2.5.2 SIPAULOVI/MISHONGNOVI TREATMENT DESCRIPTION

The existing Sipaulovi/Mishongnovi water system is divided into two separate systems. One system serves the upper village areas of Sipaulovi and Mishongnovi and the other system serves the lower village areas of Sipaulovi and Mishongnovi. The upper water system relies upon one existing 9 gpm well which was constructed in 1979 and is now 35 years old and is approaching its design life and should be abandoned. The lower water system relies upon one existing 90 gpm well which was constructed in 1978 and is now 36 years old and is approaching its design life and should be considered for immediate replacement. A second water source will be required, and is proposed to be drilled approximately one mile east of the existing lower village well. Hydrogeologic consulting services will need to be obtained to provide well design and development recommendations, and to provide on-site well inspection during well drilling.

The Treatment Alternative would combine the upper and lower water systems and utilize one treatment facility located near the re-drilled lower well and the existing 75,000 gallon lower village water storage tank. A transmission main between the second water source well and the treatment facility would be needed to convey untreated well water to the treatment facility. A booster pump at the treatment facility would boost treated water stored in the existing lower village tank up to a proposed 100,000 gallon water storage tank to serve the upper water system. A transmission main would also be required between the existing lower tank and the proposed upper village tank. Backup generators would be required at each well site and the treatment facility to provide power during power outages.

6.2.5.3 Shungopavi Treatment Description

The existing Shungopavi water system is supplied by one water source, the Shungopavi Well, which produces 65 gpm. The Shungopavi well was constructed in 1969 and is now 45 years old and has exceeded its design life. The existing Shungopavi well should be considered for immediate replacement in this Treatment Alternative. Hydrogeologic consulting services will need to be obtained to provide well design and development recommendations for the Shungopavi well re-drill, and to provide on-site well inspection during well drilling.

A second water source is required for each system, to provide redundancy and to provide water during servicing of the first water source. Another Shungopavi well known as the "New Shungopavi Well" was drilled in 2008 and was not placed into service due to the high arsenic concentration it produced. The New Shungopavi well would need a pump and motor, electrical controls, and electric power, to serve as a second water source for Shungopavi.

The Shungopavi water treatment facility would be sited next to the re-drilled existing Shungopavi well and the existing Shungopavi water storage tank, where electric power exists. A water transmission main would need to be constructed from the New Shungopavi Well to the treatment facility, to transport untreated water to the treatment facility. Water from both Shungopavi wells would flow through the treatment facility under the head provided by the well pumps. Treated water would be stored in the existing Shungopavi elevated water storage tank. Backup generators are required at each well site and the treatment facility to provide power during power outages.

6.2.6 Environmental Impacts of Treatment

The Treatment Alternative would include groundwater pumping from existing wells, rehabilitation of one well, replacing three wells at Second Mesa, and the addition of a new well at First Mesa. Groundwater would be impacted through increased pumping during the project planning period, from

206 GPM initially to 392 GPM in 20 years. A hydrogeological study will need to confirm the N aquifer is an adequate source of domestic water for the three community water systems. The proposed pumping rate would result in a drawdown of the aquifer, which is believed to be minor. Less acreage of vegetation would be directly impacted by pipeline construction, since the amount of pipeline would be reduced from about 34 miles for the HAMP alternative to approximately 10 miles for the treatment alternative. Construction impacts would be minimized by reseeding and removing invasive weeds. By clearing trees outside the migratory bird nesting season, which is March 1 – August 31, impacts to migratory birds can be avoided. If construction must take place during this period, trees will be surveyed by biologists to prevent adverse impacts. In addition, impacts to tribally sensitive Golden eagles and red-tailed hawk nests would be avoided by inspection by a biological observer. Power lines would be designed to comply with avian-protective design features. Construction activities will be designed to protect slopes and equipment will be operated in accordance with federal workplace noise standards.

No cultural or biological resource surveys have been conducted to date for the Treatment Alternative.

There would be no ephemeral stream crossings, although other potential surface water impacts would be mitigated by the preparation of a storm water pollution prevention plan and by conforming to Section 401 water quality certification requirements. Best management practices will be used to reduce the potential for erosion. While neither alternative would impact current or future population growth, construction of the arsenic treatment plants and related infrastructure would provide short-term jobs. Public health and safety would be enhanced through this project by improving both drinking water quality and quantity.

6.2.7 Land Requirements

All land required for the Treatment Alternative is Hopi Tribal trust land, with the BIA acting as trustee. The Hopi Tribe is the landowner and maintains title and definitive jurisdiction over Hopi lands (see letter from the Hopi Chairman, Appendix G). BIA and ADOT Rights-of-Way, of varying widths, exist throughout the project planning area and aspects of the Treatment Alternative would encroach into the rights-of-way at varying locations. These encroachments include pipeline alignments located in the shoulder of existing paved and dirt roads, perpendicular road crossings, and alignment segments located within the pavement section due to terrain or other constraints. BIA and ADOT right-of-way encroachment permits would be obtained before construction.

Local village concurrence on the location of water facilities and pipeline routes would need to be obtained by the Tribe, most likely through a project participation MOA signed by the Tribe and each village.

6.2.8 Potential Construction Issues

The drilling and construction of two new village wells and two village replacement wells is required before the Treatment Alternative could be deemed completely feasible. Well drilling costs have been estimated, but whereas well drilling is notoriously prone to risk to the well driller and owner alike, the proposed wells can only be counted as assumptions until fully drilled, constructed, and developed, and their well yield and water quality known.

The Hopi observe several religious ceremonies and dances throughout the year. Construction activities are generally not scheduled within the immediate vicinity of the villages during dances or other ceremonies. Construction cessation periods would have to be identified and included in the Treatment Alternative contract documents.

6.2.9 Sustainability Considerations

The Treatment Alternative is not considered to be the most sustainable alternative, in comparison to the HAMP, which is a non-treatment alternative. As previously mentioned, the degree of operator skill required to adequately operate and maintain a treatment system is high, and the lack of skilled and trained operators in the villages does not bode well for the sustainability of the proposed treatment systems.

The Life Cycle Cost Analysis and Comparison of Arsenic Mitigation Alternatives (GHD and OEM, 2014), section 5.3.2, compares the non-cost criteria of the HAMP and Treatment Alternatives. The conclusion of the life cycle cost analysis report is that the Treatment Alternative ranks high in complexity and operator skills required, while also ranking only medium on reliability, sustainability, and safety.

The complexity of operations is high simply because of the type and number of tasks necessary to adequately operate and maintain the treatment system, with daily and often hourly adjustments to the treatment process needed. High operator skill is required to adjust and monitor chemical addition to the treatment process, and to troubleshoot and correct complex automation and control systems.

The Treatment Alternative's reliability is considered medium because of the possibility of mechanical failure or operator failure, leading to arsenic non-compliance. Its sustainability is rated at medium because of the real possibility of lack of certified local operators, requirement to maintain and stock adequate pre-treatment chemicals, and requirements to periodically repair and replace the electro-mechanical treatment systems. Its safety is also rated medium as the utility operators will be required to handle hydrochloric acid and sodium hypochlorite in the pre-treatment process.

Conversely, the non-treatment HAMP Alternative is considered to be the most sustainable of the alternatives herein analyzed, in all regards. Its operability, reliability, efficiency, low complexity, cost effectiveness, and safety are all greater than that of the other alternatives.

6.2.10 Treatment Alternative Capital Cost Estimates

Please note that the following capital cost estimates are best estimates only and are based on the treatment alternative conceptual level design. If the treatment alternative were to be selected for construction, then a more precise cost estimate would be generated and made available upon completion of a final 100% design.

TABLE 6.7 – TREATMENT ALTERNATIVE CAPITAL COST SUMMARY

Water System	Cost
FMCV	$ 5,704,000
Sipaulovi-Mishongnovi	$ 4,653,000
Shungopavi	$ 2,798,000
Total Cost of Treatment	**$13,155,000**

TABLE 6.8 – FMCV TREATMENT CAPITAL COST ESTIMATE

Schedule A: Planning and Design

Item	Description	Quantity	Units	Units Cost	Total
1	Geotechnical Investigation	1	LS	$ 50,000.00	$ 50,000.00
2	Hydrogeologic Consulting	1	LS	$ 85,000.00	$ 85,000.00
3	Land Surveying	1	LS	$ 10,000.00	$ 10,000.00
4	Well Drilling (new 255 gpm well)	2,000	FT	$ 500.00	$ 1,000,000.00
5	Environmental Assessment	1	LS	$ 25,000.00	$ 25,000.00
6	Utility Management Plan	1	LS	$ 20,000.00	$ 20,000.00
				Construction Total:	**$ 1,190,000.00**

Schedule B: Construction

Item	Description	Quantity	Units	Units Cost	Total
7	200,000 Gallon Water Storage Tank	1	LS	$ 260,000.00	$ 260,000.00
8	Backup Generators	4	EA	$ 100,000.00	$ 400,000.00
9	8" Water Main, 235 PSI rated	27,050	LF	$ 35.00	$ 946,750.00
10	8" Gate Valves	10	EA	$ 1,700.00	$ 17,000.00
11	Air Relief Valves	2	EA	$ 2,750.00	$ 5,500.00
12	Power Line Extension	1.1	MILE	$ 120,000.00	$ 132,000.00
13	Rehabilitate Existing Well #5	1	LS	$ 65,000.00	$ 65,000.00
14	60 hp Submersible Well Pump, Controls, Drop Pipe, etc.	1	LS	$ 100,000.00	$ 100,000.00
15	Arsenic Treatment Facility	1	LS	$ 702,000.00	$ 702,000.00
16	East Polacca Tank Interconnection	1	LS	$ 20,000.00	$ 20,000.00
17	Telemetry	1	LS	$ 50,000.00	$ 50,000.00
18	Road Excavation and Repair - Unpaved Open Cut	2,300	LF	$ 26.00	$ 59,800.00
19	Road Excavation and Repair - Paved Open Cut	150	LF	$ 170.00	$ 25,500.00
	West Tank Dedicated Fill From PZ1				
20	8" Water Main	2,450	LF	$ 45.00	$ 110,250.00
21	Altitude Valve and Vault	1	LS	$ 30,000.00	$ 30,000.00
22	West Tank Connection	1	LS	$ 20,000.00	$ 20,000.00
				Construction Total:	**$ 2,943,800.00**

Schedule C: O&M Support

Item	Description	Quantity	Units	Units Cost	Total
23	1-Year Start-Up Assistance	45	DAYS	$ 500.00	$ 22,500.00
24	O&M Materials, Equipment and Space	1	LS	$ 40,000.00	$ 40,000.00
25	O&M Manual Development	1	LS	$ 30,000.00	$ 30,000.00
				Post Construction Total:	**$ 92,500.00**

Planning & Design Total (Schedule A)	**$1,190,000.00**	
Construction Total (Schedule B)	**$2,943,800.00**	
O&M Support Total (Schedule C)	**$ 92,500.00**	
Contingencies, 10% (Schedules A, B, & C)	**$ 422,630.00**	
Subtotal		**$ 4,648,930.00**
TERO/Tribal Tax, 0.5%	**$ 23,244.65**	
Tribal Administrative Support Fee	**$ 95,228.60**	
Tribal Fees		**$ 118,473.25**
IHS Engineering Program Support, 6% (EPS)	**$ 278,935.80**	
Outside Engineering (A&E)	**$ 100,000.00**	
IHS Project Technical Support Fee, 12% (PTS)	**$ 557,871.60**	
PTS, EPS, A&E		**$ 936,807.40**
	Total Phase Cost	**$ 5,704,210.65**
	Rounded	**$ 5,704,000.00**

TABLE 6.9 – SIPAULOVI MISHONGNOVI TREATMENT CAPITAL COST ESTIMATE

Schedule A: Planning and Design

Item	Description	Quantity	Units	Units Cost	Total
1	Geotechnical Investigation	1	LS	$ 30,000.00	$ 30,000.00
2	Hydrogeologic Consulting	1	LS	$ 60,000.00	$ 60,000.00
3	Land Surveying	1	LS	$ 10,000.00	$ 10,000.00
4	Well Drilling	1,000	FT	$ 500.00	$ 500,000.00
5	Environmental Assessment	1	LS	$ 25,000.00	$ 25,000.00
6	Utility Management Plan	1	LS	$ 20,000.00	$ 20,000.00
				Construction Total:	**$ 645,000.00**

Schedule B: Construction

Item	Description	Quantity	Units	Units Cost	Total
7	100,000 Gallon Water Storage Tank	1	LS	$ 170,000.00	$ 170,000.00
8	Backup Generators	2	EA	$ 75,000.00	$ 150,000.00
9	6" Water Main, 235 PSI rated	19,050	LF	$ 30.00	$ 571,500.00
10	6" Gate Valves	10	EA	$ 1,500.00	$ 15,000.00
11	Air Relief Valves	4	EA	$ 2,750.00	$ 11,000.00
12	Electric Power Drop	1	EA	$ 15,000.00	$ 15,000.00
13	Existing Lower Sipaulovi Well - Replacement	1,000	FT	$ 500.00	$ 500,000.00
14	40 hp Submersible Well Pump, Controls, Drop Pipe, etc.	2	LS	$ 85,000.00	$ 170,000.00
15	Arsenic Treatment Facility	1	LS	$ 498,000.00	$ 498,000.00
16	Upper Sipaulovi/Mishongnovi Master Meter	1	LS	$ 10,000.00	$ 10,000.00
17	Lower Sipaulovi Tank Interconnection	1	LS	$ 20,000.00	$ 20,000.00
18	Telemetry	1	LS	$ 50,000.00	$ 50,000.00
19	Road Excavation and Repair - Unpaved Open Cut	2,400	LF	$ 26.00	$ 62,400.00
20	Road Excavation and Repair - Paved Open Cut	2,400	LF	$ 170.00	$ 408,000.00
21	Paved Road Crossing - Bore with Casing	100	LF	$ 450.00	$ 45,000.00
				Construction Total:	**$ 2,695,900.00**

Schedule C: O&M Support

Item	Description	Quantity	Units	Units Cost	Total
22	1-Year Start-Up Assistance	45	DAYS	$ 500.00	$ 22,500.00
23	O&M Materials, Equipment and Space	1	LS	$ 40,000.00	$ 40,000.00
24	O&M Manual Development	1	LS	$ 30,000.00	$ 30,000.00
				Post Construction Total:	**$ 92,500.00**

Planning & Design Total (Schedule A)	**$ 645,000.00**	
Construction Total (Schedule B)	**$2,695,900.00**	
O&M Support Total (Schedule C)	**$ 92,500.00**	
Contingencies, 10% (Schedules A, B, & C)	**$ 343,340.00**	
Subtotal		**$ 3,776,740.00**
TERO/Tribal Tax, 0.5%	**$ 18,883.70**	
Tribal Administrative Support Fee	**$ 77,784.80**	
Tribal Fees		**$ 96,668.50**
IHS Engineering Program Support, 6% (EPS)	**$ 226,604.40**	
Outside Engineering (A&E)	**$ 100,000.00**	
IHS Project Technical Support Fee, 12% (PTS)	**$ 453,208.80**	
PTS, EPS, A&E		**$ 779,813.20**
	Total Phase Cost	**$ 4,653,221.70**
	Rounded	**$ 4,653,000.00**

TABLE 6.10 – SHUNGOPAVI TREATMENT CAPITAL COST ESTIMATE

Schedule A: Planning and Design

Item	Description	Quantity	Units	Units Cost	Total
1	Hydrogeologic Consulting	1	LS	$ 25,000.00	$ 25,000.00
2	Land Surveying	1	LS	$ 5,000.00	$ 5,000.00
3	Environmental Assessment	1	LS	$ 20,000.00	$ 20,000.00
4	Utility Management Plan	1	LS	$ 20,000.00	$ 20,000.00
				Construction Total:	**$ 70,000.00**

Schedule B: Construction

Item	Description	Quantity	Units	Units Cost	Total
5	Backup Generator	2	EA	$ 75,000.00	$ 150,000.00
6	8" Water Main, 235 PSI rated	5,150	LF	$ 30.00	$ 154,500.00
7	6" Gate Valves	6	EA	$ 1,500.00	$ 9,000.00
8	Air Relief Valves	1	EA	$ 2,750.00	$ 2,750.00
9	40 hp Submersible Well Pump, Controls, Drop Pipe, etc.	2	LS	$ 85,000.00	$ 170,000.00
10	Existing Shungopavi Well - Replacement	1,600	FT	$ 500.00	$ 800,000.00
11	Arsenic Treatment Facility	1	LS	$ 479,000.00	$ 479,000.00
12	Telemetry	1	LS	$ 50,000.00	$ 50,000.00
	Existing Shungopavi Tank Connection	1	LS	$ 20,000.00	$ 20,000.00
13	Road Excavation and Repair - Unpaved Open Cut	1,400	LF	$ 26.00	$ 36,380.00
				Construction Total:	**$ 1,871,630.00**

Schedule C: O&M Support

Item	Description	Quantity	Units	Units Cost	Total
14	1-Year Start-Up Assistance	45	DAYS	$ 500.00	$ 22,500.00
15	O&M Materials, Equipment and Space	1	LS	$ 40,000.00	$ 40,000.00
16	O&M Manual Development	1	LS	$ 30,000.00	$ 30,000.00
				Post Construction Total:	**$ 92,500.00**

Planning & Design Total (Schedule A)	**$ 70,000.00**	
Construction Total (Schedule B)	**$1,871,630.00**	
O&M Support Total (Schedule C)	**$ 92,500.00**	
Contingencies, 10% (Schedules A, B, & C)	**$ 203,413.00**	
Subtotal		**$ 2,237,543.00**
TERO/Tribal Tax, 0.5%	**$ 11,187.72**	
Tribal Administrative Support Fee	**$ 47,000.86**	
Tribal Fees		**$ 58,188.58**
IHS Engineering Program Support, 6% (EPS)	**$ 134,252.58**	
Outside Engineering (A&E)	**$ 100,000.00**	
IHS Project Technical Support Fee, 12% (PTS)	**$ 268,505.16**	
PTS, EPS, A&E		**$ 502,757.74**
	Total Phase Cost	**$ 2,798,489.32**
	Rounded	**$ 2,798,000.00**

6.2.11 Treatment Alternative O&M Cost Estimates

The Life Cycle Cost Analysis and Comparison of Arsenic Mitigation Alternatives (GHD and OEM, 2014) details the O&M requirements for the Treatment Alternative, per village, with associated costs. Those costs are summarized in Tables 6.11, 6.12, and 6.13, below.

Table 6.11 – FMCV Arsenic Treatment O&M Cost Estimate

O&M Cost Category	Estimated Annual Cost
Salaries and Benefits	$ 66,300
Administration	$ 34,500
Insurance	$ 4,000
Electricity	$ 65,000
Chemicals & Media	$ 32,000
Analytical	$ 5,500
Regular Maintenance/Repairs	$ 15,000
Specialized Contractor Maintenance	$ 60,000
Residuals Disposal	$ 40,000
Fuel/Supplies	$ 8,000
Vehicle O&M	$ 7,000
Miscellaneous & Contingency	$ 34,000
Total	**$371,300**

Table 6.12 – Sipaulovi Mishongnovi Arsenic Treatment O&M Cost Estimate

O&M Cost Category	Estimated Annual Cost
Salaries and Benefits	$ 53,000
Administration	$ 8,500
Insurance	$ 2,500
Electricity	$ 23,800
Chemicals & Media	$ 5,500
Analytical	$ 5,500
Regular Maintenance/Repairs	$ 10,000
Specialized Contractor Maintenance	$ 40,000
Residuals Disposal	$ 20,000
Fuel/Supplies	$ 5,000
Vehicle O&M	$ 3,500
Miscellaneous & Contingency	$ 18,000
Total	**$195,300**

TABLE 6.13 – SHUNGOPAVI ARSENIC TREATMENT O&M COST ESTIMATE

O&M Cost Category	Estimated Annual Cost
Salaries and Benefits	$ 44,200
Administration	$ 15,200
Insurance	$ 2,500
Electricity	$ 23,600
Chemicals & Media	$ 5,600
Analytical	$ 5,500
Regular Maintenance/Repairs	$ 10,000
Specialized Contractor Maintenance	$ 40,000
Residuals Disposal	$ 20,000
Fuel/Supplies	$ 5,000
Vehicle O&M	$ 9,000
Miscellaneous & Contingency	$ 18,000
Total	**$198,600**

6.2.12 TREATMENT ALTERNATIVE R&R COST ESTIMATE

The Life Cycle Cost Analysis and Comparison of Arsenic Mitigation Alternatives (GHD and OEM, 2014) outlines the Repair and Rehabilitation (R&R) requirements for the Treatment Alternative, per village, with associated costs. Those costs are summarized in Table 6.14 below.

TABLE 6.14 – ARSENIC TREATMENT 20-YEAR R&R COST ESTIMATE

	Replacement Costs	Rehabilitation Costs	Total
FMCV	$1,316,000	$ 304,000	$1,620,000
Shungopavi	$ 64,000	$ 200,000	$ 264,000
Sipaulovi/Mishongnovi	$ 185,000	$ 356,000	$ 541,000
Arsenic Treatment Total	**$1,565,000**	**$ 860,000**	**$2,425,000**

6.3 The Non-Treatment Alternative (HAMP)

The Non-Treatment Alternative is generally known as and referred to as the HAMP. This alternative is a regional water system concept, with water production from the recently drilled and developed Turquoise Trail Wells #2 and #3, located approximately 15 miles north of Second Mesa. A piped water transmission network is required in the HAMP concept to deliver water from the Turquoise Trail Wells to the water systems at First and Second Mesa. See Appendix A for maps of the Non-Treatment (HAMP) Alternative.

6.3.1 Design Criteria, Non-Treatment Alternative

The design criteria and design assumptions for the Non-Treatment Alternative are as follows:

- Planning period of 20 years used for facility sizing (may be different than facility useful life);
- Geometric population growth rate of 1.8% per year assumed over the planning period;
- Average per capita water consumption is assumed to increase by up to 50% by the end of the planning period;
- Reported village water production is assumed to be equivalent to total per capita water consumption;
- Average annual village water production is used to project water demands, with a multiplier of 1.5 (Navajo Area IHS peak factor, see Appendix H) to account for variations in seasonal water usage, such as during peak summer months, or during times of the year that religious festivals increase monthly and daily water demands;
- Water sources and water delivery facilities should be sized to handle expected peak flows;
- Identification of a well field with source water meeting all primary drinking water MCLs, including arsenic, which would need no treatment other than possibly disinfection;
- Water source wells must have the capacity to meet the combined village water system's demands in 12 hours of pumping, following Navajo Area IHS Guidelines;
- More than one water source well is required, to provide redundancy and allow for down-time for maintenance operations;
- The well field must be a viable water source with the capacity to meet the design demand for the duration of the design life of the project;
- Power needs at the Turquoise Trail Wells and Radio Tower Booster Station will be provided through an APS power line extension;
- Where grid power exists, diesel generators must also be provided as backup power, in the event of an extended, multi-day power outage;
- The Tribe will contract out the refueling/fuel-delivery requirement for any generators required;
- Water storage requirements for the Non-Treatment Alternative are per Navajo Area IHS Guidelines: 2.5 days of water storage, plus any fire flow reserves, less the production from the remaining water sources over 18 hours, assuming the largest producing well is out of service;
- Water storage for fire flow reserves is omitted, as none of the affected Villages have firefighting capabilities;
- Existing village water sources will not be used for drinking water;

- The Villages will purchase bulk water from the newly created HPUA and will continue to own and operate their own respective distribution systems;
- The Villages will ultimately be responsible for maintaining disinfection throughout their distribution systems;
- The Villages will be responsible for the payment to the HPUA for the bulk water delivered, and collection of utility fees from each Village's individual customers will continue to be a Village responsibility;
- The HPUA will meter the quantity of water delivered to each village and distribute the costs of water delivery to its customers on a pro-rata basis.

6.3.2 HAMP Alternative Maps

See Appendix A for maps and diagrams of the HAMP Alternative.

6.3.3 Findings from Turquoise Trail Wells #2 and #3

The recently completed Turquoise Trail Wells #2 and #3 meet the design criteria for the Non-Treatment Alternative, for arsenic concentration, yield, and long-term capacity.

The arsenic concentration of Well #2 was found to be 4.7 ppb, and the arsenic concentration of Well #3 was found to be 4.2 ppb, both less than half the arsenic MCL for drinking water, and typical for groundwater arsenic concentrations of that region.

Table 6.15 summarizes the findings from Turquoise Trail Wells #2 and #3.

Table 6.15 – Summary of Results for Turquoise Trail Wells #2 and #3

	Turquoise Well #2	Turquoise Well #3
Completion Date	October 2013	March 2014
Total Cased Depth	2,180 FT BGL	2,241 FT BGL
Borehole Diameter	18-inch	22-inch
Casing Diameter	12-inch	12-inch
Production Formation	Navajo Sandstone	Navajo Sandstone
Maximum Test Pump Rate	350 GPM	321 GPM
Expected Production Rate	415 GPM	415 GPM
Proposed Pump Set Depth	900 FT BGL	900 FT BGL
Screened Interval	1,694 - 2,174 FT BGL	1,752 – 2,217 FT BGL
Arsenic Concentration	4.7 ppb	4.2 ppb
Static Water Level (6/18/2014)	444.9 FT BGL	451.2 FT BGL
Expected 40-year Pumping Water Level	764 FT BGL	782 FT BGL
Ground Elevation	5,890 FT ASL	5,895 FT ASL

Bohannan Huston (BHI), through their subcontractor, John Shomaker and Associates (JSAI), provided well inspection during construction of the Turquoise Trail Wells #2 and #3, and also provided well design and development recommendations. Full water quality results, well completion diagrams, and lithologic logs may be found in the final well report (Shomaker, 2014) for the Turquoise Trail Wells, published by JSAI. The final well report acknowledged that the potential yield of the wells was up to 415 GPM. Although each well was test pumped at only 300 – 350 GPM, the drawdown was minimal in comparison to the available drawdown. JSAI estimated that the 40-year pumping water level would be approximately 790 feet BGL. With the top of the well screens both set at more than 1,690 feet BGL, there would still be more than 900 feet of available drawdown at the 40-year mark.

In summary, Turquoise Trail Wells #2 and #3 are both outstanding drinking water production wells, which require no primary water treatment, and which have the yield and capacity to provide the Villages of First and Second Mesa with drinking water throughout their expected useful life of 40 or more years.

6.3.4 Detailed Description of the HAMP Alternative

The Non-Treatment Alternative, or HAMP, consists of two water source wells, Turquoise Trail #2 and #3, and a regional water transmission network delivering arsenic-compliant water from the Wells to the villages of FMCV, Shungopavi, Sipaulovi, and Mishongnovi.

6.3.4.1 Operation of the Wells

The conceptual design for the well pumping scheme is for a 100 hp submersible pump to be placed in each well, which will pump to the ground surface. A Wesley Tool, which allows multiple pumps to be installed in parallel in a well, nestled one above another, may be used to install two pumps in each well, to provide redundancy. At the surface, the water will need to be boosted to the Radio Tower Water Storage Tank by means of a 60 hp pump. The conceptual design is for the ground level booster to be a submersible pump and motor, placed in a pitless unit adapter.

Electric power is not currently available at the well sites, but will be required for the reliable operation of the wells. The Tribe is in the process of obtaining a preliminary power design and quote from APS to extend power approximately 15 miles from Shungopavi to the well sites. A diesel generator will be provided at each well for backup power.

A well pump control (and tank level control) scheme will be selected before final design, and may be time clock control, pressure switch (CLONE) control, telemetry control based on the Radio Tower Water Storage Tank water level, or a combination of one of those options. In the case of telemetry or CLONE control, an alternating relay switch would be installed at each well, to provide for alternating operation of the two wells.

Soft starters or variable frequency drives will be used to minimize the starting amperages of the well pump motors. Care must be taken to coordinate pump ramp-up times with the recommendations of the pump manufacturer, to prevent undue wear on the pump thrust bearings.

When line power is available, and the specified control system calls for water production from the well, the 100 hp submersible pump will start pumping water first. The 60 hp ground level submersible pump will start thereafter, after a short delay. When the control system indicates that water production is no longer necessary, the 60 hp pump will shut-down first, with the 100 hp pump shutting down shortly thereafter.

When line power is unavailable, and the specified control system calls for water production from the well, the backup diesel generator will power on automatically, and once up to running speed, will then proceed to start the 100 hp pump first, in the same sequence as mentioned above for line power. When the control system indicates that water production is no longer necessary, the 60 hp pump will shut-down first, with the 100 hp pump shutting down shortly thereafter, and the diesel generator shutting down last.

6.3.4.2 Selection and Operation of the HAMP Disinfection Facilities

Disinfection of the HAMP water transmission mains is recommended, to deter any potential microbial growth in the transmission mains and water storage tanks. One disinfection facility will be sited at each Turquoise Trail Well and will power on simultaneously with the well pumps, to provide disinfection when the well pumps are delivering flow. A flow switch is recommended, as a redundant means of ensuring that flow exists in the transmission main before the disinfectant is introduced into the main.

The conceptual design is for disinfection to occur through chlorination with solid calcium hypochlorite tablets. A stream of water from the transmission main is diverted to a calcium hypochlorite chlorinator, where the un-chlorinated water dissolves the solid calcium hypochlorite tablets. A weak solution of chlorinated water is generated from the dissolution of the tablets, and is then injected into the transmission main. Calcium hypochlorite tablets are generally safe to handle and store, and do off-gas or emit chlorine vapor while in their solid state. Because of their high chlorine content per tablet (65% by weight) compared to liquid sodium hypochlorite (9-12% by weight), the tablets are shipped and stored in plastic 55-pound pails. The use of calcium hypochlorite tablets eliminates the need for bulk liquid chlorine storage, liquid chlorine transfer facilities, and liquid chlorine spill containment, which would be needed with liquid sodium hypochlorite.

Chlorine gas is not being considered for disinfection because of its extreme volatility, lethal nature, difficulty in handling, and need for specialized operator safety training. Chlorine gas has been used for disinfection by Tribes in the past, but discontinued due to its dangers and difficulties. For example, the San Carlos Apache and White Mountain Apache have both abandoned their chlorine gas facilities in favor of safer and easier chlorination methods.

Other potential disinfection methods, which are not being considered for the HAMP, due to various reasons, are: mixed oxidant (MIOX), chloramination, chlorine dioxide, ultraviolet radiation (UV), ozone, and chlorinated isocyanurates.

Table 6.16 below summarizes the potential disinfection methods, with their advantages and disadvantages.

TABLE 6.16 – DISINFECTION METHODS, ADVANTAGES AND DISADVANTAGES

Disinfection Method	Advantages	Disadvantages
Calcium Hypochlorite (solid tablets)	Ease of handling, storage, and shipping. Solid chemical, no spill containment required. Generally safe, stable product. Injected solute is relatively dilute at 100-300 ppm.	Not an off-the-shelf product.
Sodium Hypochlorite (liquid chlorine bleach)	Available off-the-shelf as household liquid chlorine bleach.	Difficulty of storage, handling, and shipping. Degradation of product with time and temperature. Need for spill containment
Chlorine Gas (Cl_2)	Potent, high strength, low product cost.	Dangerous, must suit-up to switch out gas bottles, specialized safety precautions and training needed.
Mixed Oxidant (MIOX)	Disinfectant is created from NaCl (salt), a stable, readily available, solid mineral.	Electrical energy required for the electrochemical reaction. Requires extensive skilled maintenance.
Chloramination	Creates a long lasting chlorine residual.	Not a strong disinfectant, recommended only for maintenance of a residual. Chloramines must be generated on-site. Care must be taken to prevent the formation of nitrogen trichloride.
Chlorine Dioxide	An efficient disinfectant.	Chlorine dioxide must be generated on-site. Generation of chlorine dioxide requires chlorine gas.
Ultraviolet Radiation	No disinfection byproducts.	High capital cost. Provides no chlorine residual.
Ozone	Excellent disinfection capabilities.	Highest capital cost. Ozone is a hazardous gas. Provides no chlorine residual. Must be generated on-site.
Chlorinated Isocyanurates (solid tablets)	Solid chemical, no spill containment required. Generally safe, stable product.	Formation of cyanuric acid and nitrogen trichloride.

6.3.4.3 Water Transmission Main Sizing and Routing

The water transmission mains were sized to adequately handle the expected design flows over the planning period (through 2035), without consideration of the BIA water systems or Tawa'ovi. Three routes were chosen for the water transmission main routing, and presented to the public and to the project stakeholders. The selected routing, which approximates the shape of an inverted "Y", was the most favored during public outreach efforts. See Appendix A for water transmission main route maps.

6.3.4.4 Water Storage Tank Sizing and Locations

The HAMP proposes to construct two new water storage tanks, one called the Radio Tower Tank, located just downslope and to the north of the existing Radio Tower, north of the Hopi Cultural Center, and the other located north of Upper Sipaulovi.

The Radio Tower tank was sited at an elevation that would allow for gravity flow to the East Polacca Water Storage Tank, and is located along the proposed main to Second Mesa. Previously, this tank had been proposed as an elevated water storage tank, on a hill to the East of the main transmission main alignment. Siting the tank at the Radio Tower location allows the tank to be sited at ground level, is less costly, and is near to the same elevation as the previously proposed elevated tank.

The Upper Sipaulovi tank location was chosen at a high point, to allow the tank to provide gravity water pressure to the upper villages of Sipaulovi and Mishongnovi. At static heads, this tank will provide approximately 20 psi to the Upper Village of Sipaulovi. During high flows, the existing hydropneumatic system currently serving Upper Sipaulovi may still be needed to maintain 20 psi minimum pressure.

Navajo Area IHS design criteria were used to determine HAMP tank sizes. Water storage requirements are 2.5 days of water storage, plus any fire flow reserves, less the production from the remaining water sources over 18 hours, assuming the largest producing well is out of service. Fire flow reserves at Hopi are omitted, as there is no local firefighting organization. A summary of tank sizing calculations is included in Appendix H.

Table 6.17 – Proposed HAMP Water Storage Tanks

	Number of Tanks	Capacity (GAL)	Capacity (FT^3)	Height (FT)	Diameter (FT)	Total Storage (GAL)
Radio Tower Tank	1	260,717	34853	24	43	260,717
Upper Sipaulovi Tank	1	110,547	14778	24	28	110,547
Totals	**2**					**371,264**

6.3.4.5 Radio Tower Booster Station

A small booster pump at the base of the Radio Tower Tank will be required to boost water to the Shungopavi elevated water storage tank and to the Upper Sipaulovi Water Storage Tank. The Upper Sipaulovi Tank water level will be controlled by an altitude valve and radio telemetry. Tank level control for the Shungopavi tank will be by radio telemetry. A check valve will ensure that metered water from the Shungopavi Tank does not backflow to fill the Upper Sipaulovi Tank. This check valve prevents the use of pressure sensing to control tank levels.

The booster station will be composed of twin alternating 15 hp pumps, a backup 40 kW diesel generator, and the tank level/pump controls. Electric power will be required at the booster station site and is expected to be available upon completion of the proposed APS power line extension.

6.3.4.5 Service to the Villages

The HAMP will connect to the existing East Polacca Tank, operated by the FMCV, which is the highest gravity point in the FMCV system. Prior to the tank connection, two service vaults are required. The first will be for the use of the HPUA, and will include a gate valve, a master meter, and an in-line throttling ball valve, to slow the flow into the East Polacca Tank, to prevent the formation of negative pressures at the point where the transmission main crosses over First Mesa. The second vault will be for the use of the FMCV, and will contain an altitude valve, to control the water level of the East Polacca Tank, a sampling port for collection of water samples, and chlorination injection taps.

The West Polacca Tank currently floats on the distribution system, in pressure zone 3. The HAMP proposes to install a dedicated inlet/outlet and altitude valve on the existing tank to ensure water turnover, and to eliminate a remote pressure reducing valve (PRV) which is currently controlling tank water levels.

The HAMP will connect to the existing Shungopavi elevated water storage tank at its base, where existing inlet and outlet piping exists. Prior to the Shungopavi tank connection, two service vaults will be installed, similar to the FMCV East Tank. The first vault will be for the use of the HPUA and will contain a gate valve and master meter. The second vault will be for the use of Shungopavi, and will contain a double check valve, sample ports, and chlorination injection taps.

The connection to the Upper Sipaulovi/Mishongnovi system will be at the existing Upper System well, in between the two villages. One small vault would be required at the connection point, for installation of a master meter. Connection to the Lower Sipaulovi-Mishongnovi system would occur at the base of the existing Lower Sipaulovi Tank, with one vault for a master meter and in-line throttling ball valve, and another vault for an altitude valve and sampling port.

Chlorination for the combined Upper and Lower Sipaulovi/Mishongnovi systems is proposed to occur at the proposed Upper Sipaulovi Tank. The chlorination facility could be owned and operated by the village utility authority, or the village could contract with the HPUA to operate its chlorination facility.

The proposed Upper Tank is the most strategic and logical place from which to chlorinate, and alleviates the villages of operating a lower system chlorinator, and possibly even a separate chlorinator for the Upper Mishongnovi system.

The proposed Upper Sipaulovi tank, the water transmission main between the proposed Upper Tank and the existing Lower Tank, and the two proposed PRVs on that main, are all proposed to be owned and operated by the HPUA.

6.3.5 Environmental Impacts of the HAMP

Groundwater would be impacted through increased pumping during the project planning period, from 206 gallon per minute (gpm) initially to 392 gpm in 20 years. A hydrogeological study confirmed the N aquifer is a good source of domestic water for this region and this pumping rate would result in a small drawdown and a minor impact on the aquifer. The floodplain effect of pipeline construction across three washes would be mitigated by burying the pipeline below the scour depth. Up to 430 acres of vegetation would be directly affected by pipeline construction and effects would be minimized by reseeding and removing invasive weeds. By clearing trees outside the migratory bird nesting season, which is March 1 – August 31, effects on migratory birds can be avoided. If construction must take place during this period, trees will be surveyed by biologists to prevent adverse impacts. In addition, impacts to tribally sensitive Golden eagles and red-tailed hawk nests would be avoided by inspection by a biological observer. Power lines would be designed to comply with avian-protective design features. Construction activities will be designed to protect slopes and equipment will be operated in accordance with federal workplace noise standards.

While 38 cultural resource sites were identified along the project route, there were several pipeline alignment changes and the location for a water storage tank was moved to avoid impacts on historic properties and traditional cultural places. The Tribe's cultural resources department surveyed all prospective construction areas and determined the project would have no adverse effect on historic properties. Several cultural sites were avoided in the design process. Cultural sites near the construction corridor will be flagged to avoid adverse effects by heavy equipment. Two cultural sites would be re-mapped, surface collected, analyzed and tested for subsurface deposits if the final pipeline alignment is in the vicinity, which is not likely. Aesthetic and visual resource impacts were considered in the siting of power lines, which will generally be along established roadways, water storage tanks and pumping stations. Land use impacts would be minor, since the tribe and villages have control over development. Improved water supply could affect economic development and land use in a positive way.

Surface water impacts at ephemeral streams and other sensitive areas are proposed to be mitigated by preparation of a storm water pollution prevention plan and conforming to Section 401 water quality certification requirements, using best management practices to reduce the potential for erosion. Pipelines will be encased in concrete across major washes and installation will comply with Section 404 nationwide permit #12 requirements. While this alternative would not affect current or future population growth, construction would provide short-term jobs and the formation of the HPUA would create long-term jobs. Communities would have improved drinking water for economic development. Public health and safety would be enhanced through the HAMP by improving both drinking water quality and quantity.

6.3.6 Land Requirements

All land required for the HAMP Alternative is Hopi Tribal trust land, with the BIA acting as trustee. The Hopi Tribe is the landowner and maintains title and definitive jurisdiction over Hopi lands (see letter from the Hopi Chairman, Appendix G). BIA and ADOT Rights-of-Way, of varying widths, exist throughout the project planning area and aspects of the HAMP Alternative would encroach into the rights-of-way at varying locations. These encroachments include pipeline alignments located in the shoulder of existing paved and dirt roads, perpendicular road crossings, and alignment segments located within the pavement section due to terrain or other constraints. BIA and ADOT right-of-way encroachment permits will be obtained before construction.

Local village concurrence on the location of water facilities and pipeline routes will need to be negotiated between Tribal and Village representatives. The Tribe has proposed a project participation MOA, to be signed by the Tribe and each village, which is a starting point for negotiations between the parties. The draft project participation MOA is found in Appendix F. The Village/Tribe MOAs should be signed by each village and the Tribe before the HAMP is determined to be completely feasible as proposed.

6.3.7 Potential Construction issues

No major foreseeable constructability issues exist for the HAMP Alternative.

The Tribe would prefer that that the Navajo Engineering & Construction Authority (NECA) perform the HAMP construction through Tribal contract. NECA currently constructs the majority of water and sewer sanitation projects for the Hopi Tribe. The Tribe believes that a significant cost savings could be realized by utilizing NECA. NECA typically does not bid on tribal construction contracts, but operates on a cost-reimbursable basis.

The Hopi observe several religious ceremonies and dances throughout the year. Construction activities are generally not scheduled within the immediate vicinity of the villages during dances or other ceremonies. Construction cessation periods should be identified and included in the contract documents.

6.3.8 Sustainability Considerations

The HAMP is considered to be the most sustainable of the alternatives herein analyzed, in all regards. Its operability, reliability, efficiency, low complexity, cost effectiveness, and safety are all greater than that of the other alternatives. See also section 5.3.2 of the Life Cycle Cost Analysis and Comparison of Arsenic Mitigation Alternatives (GHD and OEM, 2014) for more information on the comparison of non-cost criteria between the HAMP and Treatment Alternatives.

6.3.9 Capital Cost Estimate, Non-Treatment Alternative (HAMP)

Please note that the following capital cost estimate is a best estimate only and is based on the HAMP conceptual level design. If the HAMP is selected and funded for construction, then a more precise cost estimate will be generated and made available upon completion of a final 100% design.

TABLE 6.18 – HAMP COST SUMMARY

Schedule A: Planning and Design

Item	Description	Quantity	Units	Units Cost	Total
1	Geotechnical Investigations	1	LS	$ 75,000.00	$ 75,000.00
				Pre-Construction Total:	**$ 75,000.00**

Schedule B: Construction

Item	Description	Quantity	Units	Units Cost	Total
	Power Line, Generators, and Fuel Storage				
2	APS Power Line Extension	15	MI	$ 120,000.00	$ 1,800,000.00
3	375kW Generator	2	EA	$ 130,000.00	$ 260,000.00
4	40 KW Generator	1	EA	$ 45,000.00	$ 45,000.00
5	Bulk Fuel Storage Tank	2	EA	$ 45,000.00	$ 90,000.00
6	Bulk Fuel Storage Tank - 1000 GAL	1	EA	$ 15,000.00	$ 15,000.00
	Water Mains, Gate Valves, ARVs, PRVs				
7	12" Water Main, 235 PSI rated	75,300	LF	$ 48.00	$ 3,614,400.00
8	8" Water Main, 235 PSI rated	62,350	LF	$ 35.00	$ 2,182,250.00
9	8" Water Main, 305 PSI rated	5,500	LF	$ 40.00	$ 220,000.00
10	6" Water Main, 235 PSI rated	25,600	LF	$ 30.00	$ 768,000.00
	4" Water Main, 235 PSI rated	8,300	LF	$ 20.00	$ 166,000.00
11	12" Gate Valves	22	EA	$ 3,000.00	$ 66,000.00
12	8" Gate Valves	18	EA	$ 1,700.00	$ 30,600.00
13	6" Gate Valves	13	EA	$ 1,500.00	$ 19,500.00
14	4" Gate Valves	8	EA	$ 1,000.00	$ 8,000.00
15	Pressure Reducing Valve & Vault	2	EA	$ 20,000.00	$ 40,000.00
16	Air Relief Valves	15	EA	$ 2,750.00	$ 41,250.00
	Pumps and Motors				
17	100 hp Submersible Well Pump, Controls, Drop Pipe, etc	2	EA	$ 125,000.00	$ 250,000.00
18	60 hp Booster Pump, Controls, Meter, etc.	2	EA	$ 90,000.00	$ 180,000.00
19	15 hp Booster Station, Controls, etc.	1	LS	$ 140,000.00	$ 140,000.00
	Tank Level Control and Connections				
20	Altitude Valve & Vault	4	EA	$ 30,000.00	$ 120,000.00
21	Flow Control Valve	2	EA	$ 5,000.00	$ 10,000.00
22	Master Meter	4	EA	$ 10,000.00	$ 40,000.00
23	Existing Tank Interconnection	3	EA	$ 20,000.00	$ 60,000.00
24	Telemetry	2	EA	$ 50,000.00	$ 100,000.00
	Disinfection Facilities				
25	HAMP Disinfection Facility	2	EA	$ 30,000.00	$ 60,000.00
26	Village Disinfection Facility	3	EA	$ 30,000.00	$ 90,000.00
27	Power Extensions to Village Disinfection Facilities	1	LS	$ 75,000.00	$ 75,000.00
	Road Excavation and Repair				
28	Road Excavation and Repair - Unpaved Open Cut	7,050	LF	$ 26.00	$ 183,300.00
29	Road Excavation and Repair - Paved Open Cut	4,350	LF	$ 170.00	$ 739,500.00
30	Paved Road Crossing - Bore with Casing	750	LF	$ 480.00	$ 360,000.00
	Water Storage Tanks				
31	260,000 gallon Water Storage Tank	1	LS	$ 338,000.00	$ 338,000.00
32	110,000 gallon Water Storage Tank	1	LS	$ 165,000.00	$ 165,000.00
				Construction Total:	**$ 12,276,800.00**

Schedule C: O&M Support

Item	Description	Quantity	Units	Units Cost	Total
33	1-Year Start-Up Assistance	24	DAYS	$ 500.00	$ 12,000.00
34	O&M Materials, Equipment and Space	1	LS	$ 355,000.00	$ 355,000.00
35	O&M Manual Development	1	LS	$ 40,000.00	$ 40,000.00
				Post Construction Total:	**$ 407,000.00**

Planning & Design Total (Schedule A)	**$ 75,000.00**	
Construction Total (Schedule B)	**$ 12,276,800.00**	
O&M Support Total (Schedule C)	**$ 407,000.00**	
Contingencies, 10% (Schedules A, B, & C)	**$ 1,275,880.00**	
Subtotal		**$ 14,034,680.00**
TERO/Tribal Tax, 0.5%	**$ 70,173.40**	
Tribal Administrative Support Fee	**$ 282,943.60**	
Tribal Fees		**$ 353,117.00**
IHS Engineering Program Support, 6% (EPS)	**$ 842,080.80**	
IHS Project Technical Support Fee, 12% (PTS)	**$ 1,684,161.60**	
PTS &EPS		**$ 2,526,242.40**
Total Cost		**$ 16,914,039.40**
Rounded		**$ 16,914,000.00**

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6.3.10 HAMP O&M Cost Estimate

The Life Cycle Cost Analysis and Comparison of Arsenic Mitigation Alternatives (GHD and OEM, 2014) and the Hopi Water System Strategic Plan (GHD and OEM, 2014) both detail the O&M requirements for the non-Treatment Alternative, per village, with associated costs. Those costs are summarized in Table 6.19 below.

Table 6.19 – HAMP O&M Cost Estimate

Cost Category	Estimated Annual Costs
O&M Staff Salaries	$73,000
Management/Admin Staff Salaries	$96,000
Electrical Power	$105,000
Chemicals	$7,000
Analytical Costs	$6,000
Vehicle O&M Costs	$8,000
Preventative Maintenance Costs	$11,000
Repair Maintenance	$10,000
Supplies	$10,000
Contingency (10%)	$33,000
First Year Estimated O&M Costs	**$359,000**

6.2.11 HAMP Alternative R&R Cost Estimate

The Life Cycle Cost Analysis and Comparison of Arsenic Mitigation Alternatives (GHD and OEM, 2014) outlines the Repair and Rehabilitation (R&R) requirements for the HAMP Alternative, with associated costs. Those costs are summarized in Table 6.20 below.

Table 6.20 – HAMP 20-Year R&R Cost Estimate

	Estimated Annual Cost
Annual Contribution for Rehabilitation	$25,000
Annual Contribution for Replacement	$25,000
Total Annual R&R Contribution	**$50,000**

6.4 TAKE NO ACTION

The take-no-action alternative is not considered a viable alternative due to ongoing SDWA arsenic rule non-compliance. EPA enforcement has established compliance deadlines, in the form of signed compliance plans, with the affected villages. The established compliance deadline is January 23, 2015. Villages not working towards compliance may be subject to formal enforcement actions and fines.

7.0 Selection of an Alternative

7.1 Life Cycle Present Worth Cost Analysis

The Life Cycle Cost Analysis and Comparison of Arsenic Mitigation Alternatives (GHD and OEM, 2014) is a stand-alone report and contains the full life cycle present worth cost analysis for comparison of the treatment and non-treatment alternatives. This section will provide only a summary of the life cycle present worth cost analysis.

7.1.1 Life Cycle Present Worth Cost Analysis Methodology

A life cycle present worth cost analysis is an engineering economics technique to evaluate present worth and future costs for comparison of two or more alternatives. In accordance with USDA-RUS Bulletin 1780-2, the federal discount rate from Appendix C of OMB Circular A-94 is used for determining the present worth of the uniform series of O&M values over the project planning period, in today's dollars, and the salvage value, or remaining useful life of the facilities, at the end of the planning period.

In addition to the above, the life cycle present worth cost analysis criteria used to evaluate the Treatment Alternative against the HAMP Alternative is as follows:

- The analysis converts proposed planning, capital, O&M, and R&R costs to present day dollars;
- Sunken costs (expended project dollars) are not included in the analysis, as those funds are no longer available to be used for another purpose;
- Project planning period over which the analysis is evaluated is 20 years;
- The 20-year real interest rate is interpolated as the average of the 10-year and 30-year rates obtained from Appendix C of OMB Circular A-94;
- Straight line depreciation is used to determine the salvage value, or remaining useful life, of the facilities at the end of the planning period, based upon the facilities' expected design life;
- The alternatives are compared against each other based upon their calculated net present value;
- Net present value is calculated by the following equation:

  (Net Present Value) = (Capital Costs) + (Present Value of the Uniform Series of O&M Costs) + (Present Value of the Uniform Series of R&R Costs) – (Single Payment of the Present Value of the Salvage Value)

7.1.2 Life Cycle Present Worth Cost Analysis Summary

The Life Cycle Cost Analysis and Comparison of Alternatives Report analyzed the Treatment Alternative against the HAMP Alternative, with the HAMP being evaluated as two sub-alternatives: the HAMP with a 15 mile electric power line extension to the well sites, and the HAMP without the electric power line extension but with diesel generators providing primary power. A summary of the life cycle present worth cost analysis is shown in Table 7.1 below.

TABLE 7.1 – LIFE CYCLE PRESENT WORTH COST ANALYSIS SUMMARY

	HAMP with Electric Grid Power	HAMP with Diesel Generator Power	Arsenic Treatment
Capital Costs	$16,914,000	$14,588,000	$13,155,000
Annual O&M Costs*	430,000	975,000	765,000
O&M Present Value	7,032,000	15,946,000	12,502,000
Renewal & Replacement Costs	1,097,000	1,457,000	2,425,000
Total Present Value Cost	25,043,000	31,991,000	28,076,000
Remaining Useful Life	7,232,000	7,139,000	3,520,000
Net Present Value	**$17,811,000**	**$24,852,000**	**$24,556,000**

1.8% per year growth in water use assumed.
Planning period is 20 years.
Discount rate of 3.6% used in the analysis; per OMB, December 2013.
** See Table 14.2 of the HWSSP, includes costs for administration.*

7.1.3 LIFE CYCLE PRESENT WORTH COST ANALYSIS RESULTS

The life cycle present worth cost analysis demonstrates the following:

- The HAMP Alternative, with power line extension, has the lowest net present value, and therefore the lowest life cycle cost of the three alternatives analyzed;
- The HAMP with grid power alternative has the lowest total present value of the three alternatives, even without considering the remaining useful life, or salvage value, of the HAMP facilities at the end of the planning period;
- The Treatment Alternative and HAMP with generator power alternative both have lower up-front capital costs, but higher life cycle costs over the 20-year planning period;
- The HAMP with generators alternative has average yearly O&M costs which are roughly double that of the HAMP with electric grid power, due to the high consumption of diesel fuel;
- The replacement costs of the Treatment Alternative are more than twice those of the HAMP with electric grid power, due to the need to replace the arsenic treatment equipment periodically over the planning period.

The HAMP with electric grid power is the favored alternative with the lowest life cycle costs. Due to this, the HAMP with generator power sub-alternative was not evaluated further, and is not discussed at length in this report. All reference to the HAMP in this report refers to the HAMP with an APS electric power extension to the well and booster station sites.

7.2 Non-Monetary Selection Factors

The Life Cycle Cost Analysis and Comparison of Arsenic Mitigation Alternatives, section 5.3.2, compares the non-cost criteria of the HAMP and Treatment Alternatives. Sections 6.2.8 and 6.3.8 of this report further address the consideration of non-monetary selection factors. In summary, the HAMP will provide greater operability, reliability, efficiency, simplicity, cost effectiveness, and safety compared to the other alternatives analyzed, and is the alternative preferred by the Tribe.

8.0 Proposed Project (Recommended Alternative)

After consideration of the present worth life cycle costs and the non-monetary selection criteria, the Non-Treatment HAMP Alternative is the recommended alternative.

8.1 HAMP Conceptual Design

See section 6.3.4 of this report for a detailed description of the HAMP Alternative. See also Appendix A for maps of the HAMP Alternative.

8.2 Total Project Cost Estimate

Estimated Total Project Cost = **$16.914 Million**

For a detailed HAMP cost estimate please see section 6.3.9 of this report.

8.3 USDA RUS Loan and Grant Requirements

The HAMP is expected to be funded primarily through grants, tribal cash contributions, and a USDA Rural Utilities Service (RUS) loan. The USDA RUS adheres to the following criteria to compute RUS loan/grant amounts:

- The total project cost is used to determine the loan/grant amount ($16.9M for the HAMP);
- The applicant (the Tribe) may receive 45% of the total project amount as grant, or 75% as grant if the median household income (per the US Census) is less than 80% of the state non-metropolitan median household income ($50,918 for Arizona in 2010), and if the applicant is in violation of regulatory requirements;
- The total grant amount cannot exceed 75%, including other federal grant sources;
- The applicant must self-fund the remaining 25% (assuming the full 75% grant) and may do so with a combination of USDA loan monies or its own contributed funds.

The USDA RUS loan/grant application guidelines also require the following:

- Estimated monthly utility fees (to the utility customers) should be similar to other similar systems' fees, and should not be substantially less, nor substantially more;
- Audits and financial statements of the applicant;
- Evidence of legal authority and organization;
- Information demonstrating that prior or current RUS debts are in good standing;
- Submission of a PER;
- Submission of an environmental assessment or categorical exclusion statement;
- Service agreements between the applicant and the utility customers;
- Water user agreement, or evidence of a mandatory hook-up ordinance;
- List of utility authority and utility commission officers;
- Verification of the applicant's contribution;

- Evidence of insurance;
- Evidence of site control;
- A posted public notice of applicant's intent to apply for USDA RUS funding;

The above list is for informational purposes only and is not inclusive of all USDA RUS loan/grant requirements. The Tribe, as applicant, should contact the USDA RUS to discuss the application process and determine what application documentation is required. See also Appendix J of this report for reference information on USDA RUS loan/grant requirements.

8.4 Project Funding Summary

Table 8.1 – Project Funding Summary

Funding Summary	Amount	Description
Total HAMP Capital Cost	$16,914,000	Estimated cost of the HAMP scope to be completed
Maximum Possible USDA Grant	$12,685,500	75% of the total capital cost is eligible per USDA to be funded with federal grant monies
Minimum Tribal Contribution Required	$ 4,228,500	25% of the total capital cost is required from the recipient (Tribe) and may be a combination of loan and/or up-front cash, per USDA
Current Available Federal Grant Funds	$ 2,500,000	Available USEPA grant funding already appropriated to the Tribe for construction of the HAMP
Expected USDA Grant to the HAMP	$10,185,500	Maximum possible USDA grant amount less the already appropriated EPA grant monies
Expected Hopi Tribal Council Grant	$ 2,179,000	Tribal resolution pending
Expected other Hopi Tribal Cash Contribution	$ 71,000	Source to be determined
Expected USDA Loan Amount	$ 1,978,500	Minimum tribal contribution required less the expected Hopi Tribal Council grant and Hopi cash contributions

8.5 Project Contributions To Date

Table 8.2 – Total Contributions to Date

Funding Agency	IHS Project Number	Total	Available Funds
EPA	PH 14-U62	$ 985,000	$ 817,400
EPA	PH 12-E73	$ 1,233,458	$ 1,061,600
EPA	PH 11-E55	$ 1,100,000	$ 621,000
EPA	PH 10-E37	$ 1,857,400	$ 0
IHS	PH 08-T38	$ 150,000	$ 0
IHS	PH 06-D33	$ 205,000	$ 0
IHS	PH 04-S63	$ 800,000	$ 0
Totals		**$ 6,330,858**	**$ 2,500,000**

Of the $6.3 million received to date, about $3.8 million has been expended on the following:

- Hydrogeologic study published by Kennedy Jenks;
- Drilling and development of the Turquoise Trail Wells #2 and #3;
- Well drilling inspection services and publishing of a final well report by John Shomaker and Associates;
- Hopi Public Water System Strategic Plan creation by GHD;
- Life Cycle Cost Analysis and Comparison of Alternatives published by GHD;
- Archeological and biological resource surveys of the project area;
- Development of an Environmental Assessment by Marron and Associates;
- Project management, conceptual project design, and engineering consultation by the IHS;
- Development and publishing of this PER.

The remaining $2.5 million in available project funds will be expended towards the HAMP in accordance with each project's respective project summary and memorandum of agreement. Note that the $3.8 million which has been expended towards developing the HAMP up to this point is no longer available for use towards another alternative and are now sunken costs. For this reason they are not included in the cost benefit analysis or in the HAMP construction cost estimate, nor will they be included in the Tribe's application for funding to the USDA.

8.6 Hopi Public Water System Strategic Plan (HWSSP)

The facilities proposed for construction under this project will be operated and maintained by the Hopi Public Utility Authority (HPUA). The Hopi Water System Strategic Plan (HWSSP) outlines the requirements for creating and establishing the HPUA and its role in operating the HAMP. The HWSSP includes projected HPUA annual operating budgets, income, expenses, personnel requirements, projected water rates, etc.

The HPUA will act as a water wholesaler to the Villages, which will continue to operate their respective water distribution systems, albeit, without the need to operate their existing water source wells.

The HPUA will operate and maintain the HAMP facilities to the point of connection to village systems, allowing for continued village autonomy with respect to their water systems. A wholesale water system is a public water system that supplies finished water to one or more other public water systems. Individual village water systems will be considered separate consecutive public water systems and the villages will be responsible for SDWA compliance and operation and maintenance of their respective systems. A consecutive system is a public water system that buys or otherwise receives some or all of its finished water from a wholesale system.

The HWSSP includes the following major elements:

- **Asset Register**
  A listing of all the major assets such as pumps, buildings, pipelines, etc. along with important characteristics such as size, expected life, and life cycle costs. This information is used to develop operating and maintenance requirements and long term financial plans to maintain the water system.
- **Operation and Maintenance Plan**
  Development and descriptions of operating and maintenance requirements, including emergency response plans, required equipment and materials, staffing/manpower needs, and O&M costs.
- **Organization and Business Plan**
  Descriptions of recommended administrative and organization requirements for long term management of the water system. This includes recommended policies, such as procurement policies and future water system connection requirements.
- **Financial Plan**
  Total costs of the water system are identified and a long term financial plan outlined. The plan identifies costs and revenue requirements, fund management, and rate structures for payment by the Villages and other users of the system.
- **Implementation Plan**
  Identification of the major tasks required to implement the HPUA as a new utility authority and as operator of the HAMP.

8.7 Estimated HAMP Costs

Table 8.3 – Estimated Total Annual HAMP Costs

Cost	Estimated Annual Cost, Year 2015
Loan Repayment	$79,000
Operation and Maintenance	$359,000
Administrative	$71,000
Replacement and Rehabilitation	$50,000
Total	**$559,000**

Table 8.4 – Estimated First Year HAMP Costs per Village and per Connection

Village	Pro-Rata Annual HAMP Cost Share (from HWSSP)	Estimated Monthly HAMP Cost per Connection (from HWSSP)	Current Representative Village Monthly Utility Cost (residential water and sewer)	Estimated Total Monthly Utility Cost per Residential Connection (water and sewer)
FMCV	$ 401,000	$52.05	$15.00	$67.05
Shungopavi	$ 85,000	$46.00	$20.00	$66.00
Sipaulovi/Mishongnovi	$ 73,000	$43.76	$27.49	$71.25
Total / Weighted Average	**$ 559,000**	**$49.82**	**$17.69**	**$67.51**

The above costs are based on current rates of per capita water usage. The estimated monthly HAMP cost per connection includes a $35 base fee per customer, and an additional usage fee of $2.55 per 1,000 gallons of water used per month.

Table 8.5 – Comparison of HAMP Rates to Kykotsmovi and Keams Canyon

	Estimated Average Total Monthly Utility Cost per Residential Connection (water and sewer)
Estimated HAMP Average	$67.51
Kykotsmovi	$55.00
Keams Canyon BIA (metered)	$56.33
Keams Canyon BIA (unmetered)	$64.50

The above estimates assume water usage of 6,550 gallons per month (current average for First and Second Mesa, see Table 5.2), or for Keams Canyon unmetered residents, the $64.50 represents the rate for a three bedroom home (Keams Canyon BIA unmetered rates are based on number of bedrooms, see Appendix H for additional rate documentation).

TABLE 8.6 – COMPARISON OF HAMP ESTIMATED RATES TO MONTHLY INCOME

	Median Annual Household Income	5% of Monthly Income	Estimated Total Monthly Utility Cost per Residential Connection (water and sewer)	Estimated Total Monthly Utility Cost as a Percent of Monthly Income
First Mesa	$43,555	$181	$67.05	1.8%
Shungopavi	$24,830	$103	$66.00	3.2%
Second Mesa	$19,667	$ 82	$71.25	4.3%
Weighted Average	**$32,043**	**$134**	**$67.51**	**2.5%**

Annual income data source: 2008-2012 American Community Survey 5-Year Estimates, US Census Bureau

The villages will realize an O&M cost savings as each village will no longer need to operate and sample their own wells. This savings is estimated to be about $5 per home per month, based on well electricity usage and well sampling costs provided by the villages. It will be at the villages' discretion whether to pass those savings on to the users in the form of reduced village monthly utility rates, or to use those savings to fund utility reserve accounts and/or other O&M needs.

Additional information on operating income projections, O&M costs, debt repayments, and reserve requirements are found in the HPWSS.

8.8 Proposed Project Schedule

The following is a tentative proposed schedule, and may vary depending upon many variables outside of the Tribe's control. The following schedule should be considered to be a best-case-scenario for funding and construction of the HAMP.

Table 8.7 – Proposed Project Schedule

Project Task	Completion Date
Distribute final PER, WSSP, and EA	September 2014
Tribe submits USDA RUS loan/grant application	December 2014
Finalize Tribe, HPUA, and Village agreements	February 2015
USDA loan/grant application approval	July 2015
Final engineering design, construction documents, and permits	July 2016
Construction advertisement and award of contract	November 2016
Construction finish	December 2018
Transfer of facilities to the HPUA	February 2019

8.9 Environmental, Permit, and Rights-of-Way Requirements

All facilities associated with this proposed project will be located on Hopi tribal trust land, for which the Bureau of Indian Affairs (BIA) acts as trustee for the United States. The BIA, as trustee, has certain administrative responsibilities; such as: issuing Rights-of-Way (ROW), approving residential leases, constructing and maintaining roads, etc. The Hopi Tribe is the landowner and has specific rights and duties; such as: proposing residential leases, maintaining residential lease records, constructing and maintaining tribal facilities, etc.

The Hopi Tribe neither applies for nor receives a ROW from the BIA for its community water and sewer facilities. As the landowner, the Tribe does not grant itself a ROW for tribal facilities and the BIA has not exercised any express or implied right to approve or disapprove of the types and locations of tribal facilities. The IHS, as a technical resource to the Tribe, does not apply for nor receive ROWs for community water and sewer facilities. Traditionally, on Hopi tribal lands, a formal ROW for public utilities has only been sought when those utilities were to be owned and operated by an autonomous entity, separate from the Tribe or the Villages.

As the proposed project is located entirely on tribal trust land and will be owned and operated by the Tribe and Villages, no ROW for the existing or proposed facilities will be required.

TABLE 8.8 – ENVIRONMENTAL AND PERMIT REQUIREMENTS

Permit Type	Status
Environmental Review	Completed, attached to the EA
Environmental Assessment (EA)	Completed
Finding of No Significant Impact (FONSI)	To be completed with the EA
Village Concurrence	Pending, need signed Village/Tribal MOAs
Rights-of-Way (ROW)	Tribal lands, no ROW required
Historic Preservation and Archeology	Surveys conducted by the Tribe, with pending SHPO concurrence
Threatened and Endangered Species (T&E)	T&E determination provided by the Tribe
Construction Permits	None required by the Tribe
Storm Water Pollution Prevention Plan	Project engineer to create the SWPPP and deliver to the contractor for implementation
EPA 401/404 Certification	Complete, see the EA for wash crossing determinations
BIA Road Crossings	Project engineer will coordinate application for road crossing permits
ADOT Road Crossings	Project engineer will coordinate application for road crossing permits
APS Service Line Agreement	APS responsibility, project engineer will coordinate with APS
Permission to Encroach Upon Home Site Lease	A home site lease search will be conducted by the Tribe and permission from lease holders sought, if applicable

9.0 Conclusions and Recommendations

In conclusion, the regional water system concept known as the HAMP is considered to be the most cost effective and sustainable of the alternatives herein analyzed. The HAMP will provide greater operability, reliability, efficiency, simplicity, cost effectiveness, and safety compared to the alternative of implementing water treatment systems in each village. The HAMP is also the alternative preferred by the Tribe and the Villages.

HAMP utility user fees are estimated to average approximately $67.51 per home per month, which is comparable to the neighboring Kykotsmovi system, immediately to the West of Shungopavi, and the BIA Keams Canyon system, directly to the East of the project area. The projected utility user fee has been calculated so as to adequately fund the utility operations of the HAMP, including reserve funds for repair, replacement, and debt servicing.

It is recommended that the Tribe finalize the project agreements with the villages as soon as possible and advance this report and other engineering documents to the USDA, along with the application for RUS funding. It is also recommended that the Tribe continue to apply for and pursue annual funding sources available through the EPA, IHS, and HUD, until full project funding is acquired.

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